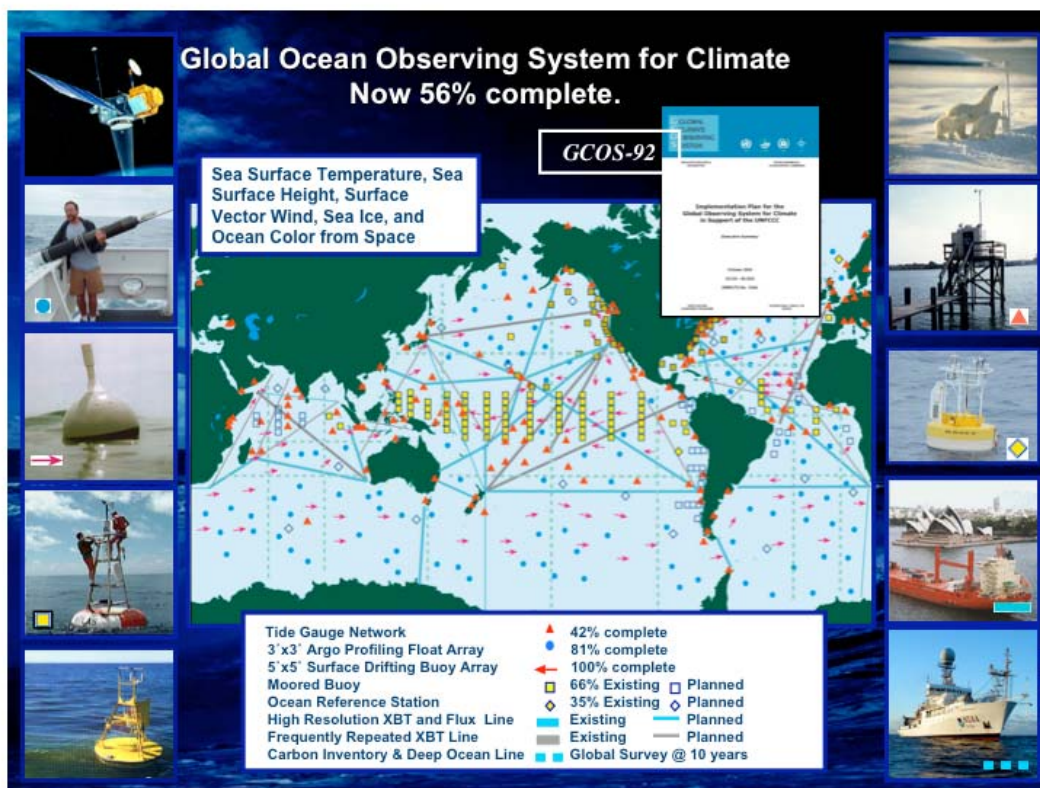


# NOAA Climate Observation Program 4<sup>th</sup> Annual System Review

Theme: Advancing the System to Address Ocean Analysis Needs

May 10-12, 2006



Sponsored by:  
**NOAA Office of Climate Observation**



**Annual System Review Report**  
**June 2006**



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**May 10-12, 2006**

## **Annual System Review Report** June 2006

*Edited by Diane Stanitski*

This report and all papers and posters presented at the NOAA Climate Observation Program 4<sup>th</sup> Annual System Review can be downloaded from the NOAA Office of Climate website at [www.oco.noaa.gov](http://www.oco.noaa.gov). Click on “Meetings” under Oceanic and then on “5/10/06 - 5/12/06 Office of Climate Observation Annual System Review Workshop”. There, you can access the ppt presentations and poster files by clicking on “Agenda” and “Posters”.

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# **2006 Climate Observation Program 4<sup>th</sup> Annual System Review**

## **Climate Observing System Council Meeting**

### **May 10-12, 2006**

#### **Meeting Summary**

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The National Oceanic and Atmospheric Administration's Climate Observation Program was initiated by the Office of Global Programs (OGP) in 1998. The Program is managed through the Office of Climate Observation (OCO), which was established on October 1, 2003 as an office to manage the climate observing system under the auspices of the NOAA Climate Program Office. The goal of the Program is to build and sustain the ocean component of the global climate observing system that will respond to the long term observational requirements of operational forecast centers, international research programs, and major scientific assessments.

In order to advance this goal, the fourth Annual System Review was held from May 10-12, 2006 in Silver Spring, Maryland. The theme of the meeting was *Advancing the System to Address Ocean Analysis Needs*, including presentation and poster sessions, a panel session, a session describing and discussing of the outcome of Chapter 2 of the Annual Report on the State of the Ocean and the Ocean Observing System for Climate, and open and executive sessions of the Climate Observing System Council (COSC).

The two-and-a-half day meeting was organized as follows:

#### **Wednesday, May 10**

Session 1 – Overview

Session 2 – Users

Session 3 – Panel Session and Discussion – Ocean Observing System Applications

Session 4 – Assimilating Data – Collaborations and Applications

Session 5 – Illustrated Poster Sessions

#### **Thursday, May 11**

Session 6 – The State of the Ocean (based on Chapter 2 contributions to the Annual Report on the State of the Ocean and the Ocean Observing System for Climate

Session 7 – Technical Requirements

#### **Friday, May 12**

Climate Observing System Council (COSC) Open and Executive Sessions

Scientists and project managers attending the meeting were invited to prepare posters highlighting their funded projects. PIs provided short introductions and an overview of their research during an Illustrated Poster session. An informal evening poster viewing session and reception enabled participants to interact while reviewing posters.

A Friday morning open discussion session with the COSC and the COSC executive session focused on the Tropical Atmosphere Ocean (TAO) transition, Observing System Monitoring Center (OSMC), Observing System Simulation Experiments (OSSEs), and the Global Ocean Data Assimilation Experiment (GODAE) with discussion following.

The COSC Executive Board met to discuss additional detailed activity within the NOAA Office of Climate Observation.

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**Climate Observation Program 4<sup>th</sup> Annual System Review**  
**Theme: Advancing the System to Address Ocean Analysis Needs**  
**10-12 May 2006**

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**MEETING REPORT**

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**WEDNESDAY, May 10, 2006**  
**Session 1: Program Overview**  
**Chair: Mike Johnson**

**Welcome**

Mike Johnson, NOAA Office of Climate Observation

Mike Johnson, Director of the Office of Climate Observation (OCO), welcomed participants to the 2006 Climate Observation Program 4<sup>th</sup> Annual System Review, held at the Crowne Plaza in Silver Spring, Maryland. He then introduced the morning session and highlighted focus areas during the meeting including user feedback; how well the observing system is supporting ocean analysis; the ocean observing system including applications in the areas of drought, hurricanes, and abrupt change; satellites and the surface/subsurface system of systems; project posters; and OSEs and OSSEs.

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**Putting the “O” in NOAA**

Ants Leetmaa, NOAA Geophysical Fluid Dynamics Laboratory

Ants Leetmaa introduced critical areas where NOAA needs to justify further study and search for understanding. These include simulation and understanding of 20<sup>th</sup> century climate; understanding of natural decadal variability for attribution studies and decadal predictions; and understanding (and predicting) links between hurricanes and climate variability and change, sea level rise, droughts, and ecosystems under stress.

The challenge is to ensure that Oceans remain a large part of what NOAA emphasizes at present and in the future. A NOAA vision for the oceans would include a systematic and sustained global ocean observing with assimilation, analysis, and forecasting capability *addressing national needs*. This will provide a basic physical framework spanning ocean basins needed for extending to ecosystem modeling/forecasting, i.e. adding the biogeochemistry and ecosystems. Help is also needed with nesting of high-resolution place-based (i.e., coastal) and event-based (i.e., hurricanes) forecast models, assessing the impact of the oceans on climate products and services from S/I and longer time scales and enabling attribution studies. Our challenge is to justify such a capability in terms of the societal needs. It was argued that sufficient justification for such a capability – in particular, the satellite components of such a global observing system – has NOT yet been made to NOAA.

Final summary points emphasized the need for an integrated global ocean observing system - *in situ* plus satellites with a major issue being continuity of ocean satellites. Now that routine

analyses of the ocean are becoming available there is a need to understand what they are telling us about the climate system. This needs to be an integral part of the broader end-to-end activity to deliver societal benefits and will help bring about the next “nOaa”.

**The Climate Observation Program;  
Program Planning, Performance Metrics, Budget**  
Mike Johnson, NOAA Office of Climate Observation

Mike Johnson introduced the meeting plan to discuss the system implementation objectives and strategy for global ocean observations, progress and funding, system status, system performance monitoring, and observing system experiments. He provided an overview of the Climate Observation Program and the climate requirements and mission for the Office of Climate Observation.

Mike emphasized that satellite observations are necessary as part of the capabilities required and we need to begin working more closely with the satellite community. A later session will allow for members of that community to share their needs for the ocean observing system.

The overall international ocean observing system is now 56% complete, with the United States contributing approximately half of the system. A total of 4725 platforms are maintained globally. The U.S. supports 2758, of which NOAA supports 2591.

In order to reach the target of initial system completion an annual budget of \$141 M will be needed. With a maximum executable ramp of \$17 M per year, the system could be complete in 2012. The FY 07 President’s Budget requests a \$6.1 M increase. The strategy for dealing with the FY 06 budget reduction of \$4.8 million remains to continue with our mission of building a Global Climate Observing System for climate. The fundamental principle remains that we cannot build a global observing system with level or declining budgets. Therefore, we do not accept declining budgets as a fact and will assume that FY 06 was a mistake. The two-year strategy is to bridge across FY 06 with minimum impact to the foundation of the infrastructure, in other words, keep building. Plans are to make our FY 07 budget transparent to Congress so the mistake will not be repeated.

FY 06 supplemental funding lessened the full impact of the budget reduction by providing Hurricane Katrina supplemental appropriation for hurricane drifters. There was a NOS IOOS earmark for Data Management and the California Current climate-ecosystem, global-coastal project. The Tropical Moored Buoy Network received a \$3M appropriated increase. Improvements to the tropical moored buoy network included expansion in 1) the Indian Ocean, 2) the PIRATA array, 3) on tropical reference stations, 4) with surface salinity, and 5) with Next Generation research and development.

Impacts of the FY 06 budget reduction included elimination of the low density XBT project one year ahead of Argo completion instead of one year after as originally planned. Transition function will be developed on a 5-year partial overlap (’01-’06) rather than a full year overlap (’07) (GCOS Climate Monitoring Principles). No new Arctic ice buoys are being deployed in FY 06. Instead, there will be experiments with low-cost surface drifters on the ice. Only one half of the ocean carbon inventory survey was supported, with half the normal density for the Tahiti to Kodiak transect line. There were across the board funding cuts of 1% to 12% on all projects except the Tropical Moored Buoy Network. The full impact of the FY 06 cut will be felt in FY

07 if the budget is not restored. With approval of the requested budget in 2007, incremental advancements across all networks and DMAC and GODAE follow-on services will be pursued.

An overview of the status of the system was presented showing 4725 platforms globally with progress made with each platform. Performance monitoring is underway to reduce the error in global measurements of sea surface temperature, ocean heat storage, sea level change, and ocean carbon sources and sinks. The system percent complete and the essential variables reported are key performance measures also monitored on an ongoing basis. It may be time to undertake a program of Observing System Simulation Experiments.

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**Session 2: Users**  
**Chair: Ed Sarachik**

**Observing System Needs of the Research Community**  
Robert Weller, Woods Hole Oceanographic Institution

The sustained ocean observing needs of the research community were reviewed. Solar heating leads to large-scale asymmetry in radiative forcing of the earth. The atmosphere is a filter that allows shortwave radiation in and traps longwave radiation. Heat that would otherwise accumulate at the equator is carried poleward by atmospheric and oceanic pathways. Anthropogenic change in greenhouse gas and aerosol concentrations is changing the radiative properties of the atmosphere; global average surface temperature is rising. Climate observations are required to quantify and address change in the storage by the ocean of properties such as heat, to determine the magnitude and any change in large-scale ocean transports, and to specify and monitor exchanges between the ocean and atmosphere. Improving surface flux fields, repeat hydrography, high resolution XBT lines, Argo floats, and surface drifters are all essential to quantifying storage, transport, and air-sea exchange. Satellite observations of SST, vector surface wind, sea surface height, surface radiation, and ocean color are key parts of the sustained ocean observing system.

Climate observations should also be directed at identifying and monitoring characteristic patterns of ocean variability, such as ENSO and the decadal modes, NAO and PDO. The predictability of these modes and thus of linked impacts on land are one pathway by which knowledge of the state and variability of the ocean lead products used by society. The TAO-Triton array is a good example of a component of the observing system designed to address improved observation and prediction of a large-scale mode, ENSO. Work is underway to extend surface moorings extra-tropically, to improve global air-sea flux fields, and thus to improve knowledge of atmosphere-ocean coupling across the global ocean.

All global moorings should evolve to be instrumented to observe physical and non-physical variables. Climate observations should address the carbon cycle as well as the physical climate. In addition to storing heat, the ocean is absorbing carbon dioxide. Repeat hydrographic section that sample tracers reveal the pathways into the interior of the ocean of anthropogenic substances as well as of water masses formed at the sea surface. Moored arrays spanning basins and at choke points also quantify transports. New technologies such as gliders are being tested to assess their capability to measure transports in key regions such as the boundary currents.

U.S. CLIVAR seeks not only to observe and understand the ocean's role in climate but also to improve the ability to predict the coupled ocean-atmosphere climate system and to see such improvements in place at major applications centers. These goals require that sustained observations of the ocean and its surface forcing be obtained to initialize, validate, and improve models. U.S. CLIVAR has restructured itself into three panels to facilitate achieving these goals: the Phenomena, Observations and Synthesis Panel (POS), the Process Study and Model Improvement Panel (PSIP), and the Prediction, Predictability, and Applications Interface Panel (PPAI). The observations needed to reach the goals of these panels include those: 1) to quantify ocean storage, air-sea exchange, and ocean transport; 2) for model initialization, forcing, and validation; 3) for discovery, detection, and empirical analyses of patterns of ocean variability; 4) to show coupling and teleconnections, thus requiring atmospheric and land surface observations; 5) for resolving key processes leading to improved understanding and better parameterization of such processes in models; 6) to allow simulation and prediction; 7) and to support transitions to applications. A goal of CLIVAR will be to leave not only a legacy of a sustained observing system but also to have in place the data assimilation and modeling to establish a prototypical system for decadal projection and prediction.

### **Observing System Simulation Experiments: Application to Indian Ocean**

Gabriel Vecchi, M. Harrison, Q. Song, A. Wittenberg, Anthony Rosati  
NOAA Geophysical Fluid Dynamics Laboratory

The proposed integrated in situ Indian Ocean observing system (IOOS) was assessed using an observing system simulation experiment (OSSE) based on a high-resolution ocean general circulation model (OGCM). The model was forced with daily-mean forcing and included an estimate of sub-daily oceanic variability derived from observations; the inclusion of sub-daily noise is fundamental to the results. The focus of this assessment is the ability of an IOOS - comprised of a 3°x3° ARGO profiling float array, a series of frequently repeated XBT lines and an array of moored buoys - to observe the interannual and sub-seasonal variability of sub-surface Indian Ocean temperature.

A fully deployed ARGO array with 10-day sampling interval is able to capture a significant part of Indian Ocean interannual temperature variability. A 5-day sampling interval degrades its ability to capture variability. A 5-day sampling interval does not drastically enhance the ability of ARGO to capture the OGCM sub-seasonal variability. However, as sampling intervals are decreased there is enhanced divergence of ARGO floats, diminished ability to quality control data, and a decreased life-time of the floats. These factors argue against attempting to resolve sub-seasonal variability with ARGO by shortening the sampling interval. The proposed moored buoy array and frequently repeated XBT lines provide complementary information in key regions, particularly in the Java/Sumatra and Somali upwelling and equatorial regions for XBT, and the near-equatorial southern Indian Ocean region of strong intraseasonal variability. On the whole, the proposed IOOS significantly enhances our ability to capture both the interannual and sub-seasonal variability in the Indian Ocean.

The design of OSSE experiments to assess observing systems needs to develop within the context of the problem being addressed, and the forecast, data assimilation and planned applications of the data being recovered. However, OSSEs provide a potentially useful tool to identify observing system deficiencies.

## **Observations in Support of Climate Risk Management**

Lisa Goddard

International Research Institute for Climate & Society

The Earth Institute of Columbia University

Several interconnected elements are necessary for managing climate-related risk, be it malaria, food security, or flood warnings. The risk or decision under consideration generally arises from local or regional user demands, such as the need to control malaria in order to help meet several of the UN's Millenium Development Goals. Necessary elements in affecting the decision process include: involvement of the appropriate social and political organizations; financial, technical and human resources; information about current or impending climate and environmental conditions; general understanding of the community or general public regarding the role of climate in addressing the risk under consideration; effective avenue(s) for dissemination of information; and most importantly, implementers with a vested interest in mitigating climate risk that can put all the pieces together. Climate information is only one piece of this effort, but it is a very important piece.

The importance of ocean observations in supporting "climate information" falls into roughly four categories. (1) Forcing: Providing oceanic boundary conditions for climate simulations, which allows us to investigate the potential predictability of climate and conduct regional/global climate diagnostics studies. (2) Initialization: Providing the initial oceanic state to climate forecasts. (3) Verification: Providing an observational check on climate models and their forecasts. (4) Diagnostics: Provide detailed information, in space and time, on oceanic processes, which is essential for identifying model errors, and hopefully contributing to model improvement.

Numerous research efforts highlight the need for high quality ocean observations. I list a number of examples below indicating the connection between tropical ocean conditions and the regional climate.

### \* Improving climate information related to tropical Pacific variability

Most, if not all, ENSO prediction models have a difficult time capturing the proper characteristics of ENSO events, including inter-event variability. We need ocean observations to better understand the physical processes before we can hope to improve the models' ability to capture both the strength and the structure of El Niño and La Niña events. The expected climate response from central Pacific focused El Nino events is different from eastern Pacific events. This has been shown observational composites of the terrestrial climate; the same is true in atmospheric general circulation models. It's very important to get ENSO 'right' because that is when we have skill in predicting climate over US, and much of the rest of the world.

### \* Improving climate information related to Indian Ocean variability

Research suggests good prediction of the Indian Ocean is important for forecasting precipitation variability over East Africa, and maybe over the US too. In experiments where the forcing from the Indian Ocean is isolated, results indicate that warm anomalies in the Indian Ocean cause positive rainfall anomalies over East Africa. The isolated forcing from the tropical Pacific, whose variability is highly correlated with that of the Indian Ocean, leads to increased subsidence and drier conditions over East Africa during El Niño conditions. Therefore, good predictions of Indian Ocean SSTs are needed but our understanding of the relevant balance of mechanisms for SST variability in that ocean basin is limited. Until recently, what 'observed' data we did have was problematic because this is where the largest sampling errors, and thus uncertainty exists.

\* Improving climate information related to tropical Atlantic variability

The potential to predict West Africa variability exists, if the Atlantic SSTs are accurate. If the SSTs cannot be predicted, neither can the regional climate. Errors in the precipitation forecasts over West Africa arise mainly from errors in predicting equatorial Atlantic SSTs. Similarly for NE Brazil, which has the highest potential predictability of any place on the planet, the explained variance of precipitation drops from ~50% to ~25% if the relevant SSTs in the tropical Atlantic cannot be predicted accurately. Coupled models have a very difficult time with the Atlantic – even getting the mean state right.

In general, most of what the dynamical models can predict outside the tropical Pacific is due to what's going on in the tropical Pacific (i.e. the influence of ENSO), and currently the dynamical models are not really beating the statistical ones. A clear need exists to improve the representation of physical processes in models. This can only happen with a high quality ocean observing system that provides data with sufficient spatial and temporal resolution. We must also be able to initiate the models as accurately as possible, which requires a sustained observing network that provides data accurately and reliably, in real-time.

To this point, the discussion has, perhaps implicitly, been more oriented toward climate information on the seasonal-to-interannual timescale. Increasingly, decision makers are interested in climate information that extends one to several decades into the future. Some turn to the climate change models, used in the IPCC process, for information on future climate variability that is perceived to be largely arising from anthropogenic climate change. Using a 'climate change projection' ignores the fact that substantial natural variability exists in the climate system with decadal-to-multidecadal timescales. The IPCC models have decadal variability, but it's not synced in time with observations. They capture the slowly evolving trends due to radiative forcing of increasing GHGs, but not the natural decadal variability. In order to use dynamical models of the climate system for decadal prediction, the ocean state must be properly initialized. We are, just now, starting to get an ocean observing system that might allow us to initialize the global ocean state, and thus to investigate the potential predictability of decadal fluctuations. Decadal fluctuation in the ocean state has discernible impacts on the terrestrial climate. For example, examination of observed precipitation associated with SST anomalies over the North Atlantic show large regions of differences between the 'warm phase' (20 years in mid-20<sup>th</sup> century) and the 'cool phase' (15 years in the early 20<sup>th</sup> century), such as wetter conditions over the Sahel and drier conditions over East Africa, much of Australia, and the western US. Interestingly, those are the sort of persistent conditions we have been observing recently, which is also considered to be 'warm phase'.

### **The Ocean Observing System as Viewed from the S/I Forecasting Perspective**

David G. DeWitt

International Research Institute for Climate and Society

The Earth Institute of Columbia University

The ocean observing system is a critical component in the effort to perform seasonal to interannual (S/I) predictions. In particular, ocean and near-surface atmospheric data are used in several aspects of the S/I prediction problem including ocean initial state specification, and validation of simulated ocean mean state and air-sea heat fluxes. Much progress has been made in the last 10 years in better sampling of the ocean and near-surface atmosphere but there is still work to be done in providing products that can more easily be used by communities such as the S/I community. In particular, the use of data sets for model validation will be made much easier if

the data are provided in an objectively analyzed gridded format with associated error bars. The observational community are the experts in this and having this community do the analysis is preferable to having individual modeling groups doing this work. Unfortunately, despite many worthwhile uses such as ocean state initialization for S/I forecasting, the current ocean data assimilation (ODA) efforts cannot be considered as replacements for observations for many fields of interest. This is clearly demonstrated when one examines the near-equatorial current systems which differ greatly between ODA products despite fairly good agreement between the ODA products in other fields such as salinity and temperature.

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### **Session 3: Panel Session and Discussion – Ocean Observing System Applications**

**Chair: Ed Sarachik**

This panel session was a first attempt to invite researchers from outside our ocean observing community to discuss the significance of ocean observations to various components of our climate system. The questions that were addressed include: How does the ocean influence drought, Atlantic circulation, and hurricane development/intensity? Do researchers studying these issues need an ocean observing system? If so, what ocean observations are necessary?

#### **Topics and Panelists**

##### **Attribution Evidence for Oceanic Forcing of Regional Droughts**

Martin Hoerling, NOAA-Earth System Research Laboratory

An overview on the current understanding of the relevant forcings for regional droughts like the multi-decadal Interior Western U.S. Drought, Sahelian Drought, and the Great Plains "Dust Bowl" was presented. What is the decision-making context and the attribution evidence used to suggest that drought is a function of oceanic forcing? A key challenge is distinguishing droughts originating from natural vs. anthropogenic sources. Has, for example, greenhouse gas forcing caused recent African drying, or is it related to natural swings of climate? Are the factors expected to occur more frequently? It is also important to distinguish trends toward increased aridity, and changes in the episodic drought events.

It was stated that the observing system requirements of the *Drought Early Warning System* may require knowledge of the global SST state, global ocean state, land surface state, and the atmospheric initial state.

Drought Attribution focuses on diagnosing causes, for example, if they are similar for warm versus cold season droughts, land versus ocean influences, and interannual versus interdecadal time scales. Advancing drought predictions requires knowledge of the expected skill and sources, and whether the factors limiting skill can be overcome.

## **Early Detection/Prediction Of Ocean Circulation Changes: Implications For The Design Of Ocean Observation Systems**

Klaus Keller, Pennsylvania State University

Analysis was conducted to show when a Meridional Overturning Circulation (MOC) observation system would detect anthropogenic MOC changes. Specifically, a Bayesian statistical framework was adopted to estimate the time required to detect the weakening MOC signal in a specific model simulation. It was concluded that decadal-scale hydrographic observation systems may well fail at early detection (*i.e.*, detecting anthropogenic MOC changes before the system is committed to an MOC threshold response). Increasing the observation frequency and/or precision can result in early detection. It is estimated that the economic value of information associated with a hypothetical MOC observation system would enable an early and confident MOC prediction. Analysis suggests that the economic value of such an MOC observation system can exceed the costs of currently implemented observation systems by orders of magnitudes. One key outstanding challenge is to identify a design of an MOC observation system that could provide a reliable early prediction of a potential MOC threshold response across the range of parametric and structural uncertainties.

K. Keller, C. Deutsch, M. G. Hall and D. F. Bradford: [Early detection of changes in the North Atlantic meridional overturning circulation: Implications for the design of ocean observation systems.](#) Journal of Climate, in press (2006).

The conclusions of research focused on this problem show that the currently well-tested praxis of relatively infrequent and uncertain Meridional Overturning Circulation (MOC) observations would likely fail in detecting MOC changes within this century. Continuing observations similar to the 26°N MOC observation array could succeed in *detecting* anthropogenic MOC changes within this century. *Prediction* of threshold crossing is the relevant task for many decision-making frameworks. Observation systems designed for early detection may fail at the task of early prediction. Adding frequent and dense tracer observations (*e.g.*, oxygen or CFC) is a promising strategy to improve the MOC prediction capabilities and may well be part of an economically efficient risk management strategy.

# **The Hurricane Coupled Boundary Layer Air-Sea Transfer (CBLAST) Experiment: Insight into Ocean Observation Strategy for Improved Hurricane Intensity Forecasts**

Presented by Peter Black, NOAA Hurricane Research Division

Peter G. Black<sup>1</sup>, Eric Uhlhorn<sup>1</sup>, Rick Lumpkin<sup>2</sup>, Gustavo Goni<sup>2</sup>, Eric A. D'Asaro<sup>3</sup>, Thomas B. Sanford<sup>3</sup>, Pearn P. Niiler<sup>4</sup>, Bill Scuba<sup>4</sup>, Eric J. Terrill<sup>4</sup>, Will Drennan<sup>5</sup>, Jun Zhang<sup>5</sup>, Nick Shay<sup>5</sup> and Edward J. Walsh<sup>6</sup>

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<sup>6</sup>NASA, Goddard Space Flight Center, Wallops Island, Virginia

The Hurricane Coupled Boundary Layer Air-Sea Transfer (CBLAST) Experiment was initiated because the ability to forecast hurricane intensity has changed little, while hurricane track forecasts have improved steadily over the past 20 years. Current understanding of the air-sea transfer process that drives hurricane intensification is based on field measurements in winds below gale force (36 mph). A gap in our knowledge exists. Improvements in operational forecasts of hurricane intensity have marginally kept up with improvements in track since 1997, but intensity forecasting still lags track significantly.

Hurricane intensity prediction requires in situ and remote sensing data to relate the OML, Atmospheric Boundary Layer, and sea surface processes in regions such as warm core eddies, the Loop Current, and the Gulf Stream before, during, and after storm passage. One can improve parameterizations with respect to coupled air/sea interactions including bulk aerodynamic coefficients ( $C_k$ ,  $C_d$ ), and develop methods to analyze the observed three-dimensional ocean response to assess processes that cool/deepen the OML and compare with model simulations.

Examples of data resources were given for Isadore and Lili in 2002 including nine NOAA WP-3D research flights before, during and after the storm, upper ocean in situ measurements in the southern Gulf of Mexico with use of 105 AXBTs for temperature, 61 AXCTD for temperature and salinity, and 91 AXCP to measure temperature and wind, surface forcing calculations, and objectively-analyzed variables on a  $3^\circ \times 3^\circ \times 750$  m domain.

The goals of the CBLAST project are to improve air-sea flux parameterization in numerical models for high wind conditions, and to improve hurricane intensity forecasts. Should we place money aside for this research, and do the end costs (billions of dollars) of Katrina warrant the research costs?

An increase in Atlantic SSTs is established driven by the NAO (is it a trend, and not a cycle?) associated with enhanced droughts and hurricane activity, both episodic events and incredibly important on the long-term climate and short-term variability scale. Katrina strengthened and then fell bringing a 30' surge more like a tsunami. Waves are not modeled accurately, but knowing surges of ocean heat (e.g., loop current, Gulf Stream) is exceedingly important. Three different areas (Rita gave a repeat scenario) enabled intensification and then weakening. Ocean observations are unequivocally necessary. We should transition into an operational mode – to maintain and improve.

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**Session 4: Assimilating Data – Collaborations and Applications**  
**Chair: Ed Harrison**

**The Link between Satellite and In Situ Observations**  
Kenneth Casey, NOAA National Oceanographic Data Center

Ken Casey presented a summary of a new chapter in this year's Annual Report called "Satellite Contributions to the Ocean Observing System for Climate", in which he stressed the need for careful reprocessing of satellite data and the critical needs for relevant in situ observations. He began by demonstrating the impact and improvements attained by the AVHRR Pathfinder reprocessing effort (<http://pathfinder.nodc.noaa.gov>) to create more accurate and consistent SSTs from the NOAA Polar Orbiting platforms. The differences between this reprocessed Climate Data Record (CDR) and the original real time SSTs from the AVHRR can be dramatic, and can, for example, even result in SST trend estimates with opposite signs for some regions. He followed with a survey of CDR efforts being conducted for SST, ocean color, ocean surface topography, marine winds, and sea ice. In each section, examples were given of the important role played by in situ observations for algorithm development, calibration, and validation of satellite-derived ocean CDRs.

**Comments on the Ocean-related Satellite Needs**  
**Identified in the GCOS Implementation Plan**  
Stan Wilson, NOAA NESDIS

The critical ocean-related satellite actions identified in the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* for which NOAA needs to take timely action are those related to sea surface height (SSH), surface vector winds (SVW), and ocean color.

If continuity of the Jason series of satellite altimeters is to be maintained, NOAA and EUMETSAT must take the lead to implement a Jason-3 to follow the NASA/CNES Jason and Jason-2 (when launched in 2008) missions; this will require a new start for NOAA in its FY09 budget.

Regarding SVW, NASA has no planned follow-on to its QuikSCAT; and when ASCAT launches on METOP later this year, it will have only ~60% of QuikSCAT swath. Based on evaluations to date, neither passive polarimetry (WindSat & NPOESS/ CMIS) nor scatterometry (QuikSCAT) are able to meet all needs. Further improvements are needed, especially resolution of the *wind vs. rain ambiguity*; this is the focus of a workshop to be hosted by the National Hurricane Center. Ideally, NASA will incorporate this in its recently initiated study of advanced concepts for scatterometers.

A variety of space observing capabilities for ocean color are in place, with NASA providing most – if not all – U.S. support (SeaWiFS & MODIS). To the extent NPOESS/VIIRS is to provide a continuing source of ocean color observations, especially for climate-quality data records, NOAA

must secure support for an independent in situ calibration capability (included in FY09 initiative with NIST), as well as a capability for algorithm refinement, routine reprocessing, and a science team (to be included in an initiative for Scientific Data Stewardship).

None of these initiatives will be successful unless the NOAA Goals and Line Offices – other than NESDIS – express their strong support.

**Operational NCEP Global Ocean Data Assimilation System:  
The Link, Validation, and Application**

Yan Xue, Boyin Huang  
Climate Prediction Center, NCEP/NOAA  
and  
David Behringer  
Environmental Modeling Center, NCEP/NOAA

A new global ocean data assimilation system (GODAS) has been developed at the National Centers for Environmental Prediction (NCEP) using the Geophysical Fluid Dynamics Laboratory's Modular Ocean Model version 3 (MOM.v3) and a three-dimensional variational data assimilation scheme. A retrospective global ocean reanalysis for 1979-2004 has been generated. The GODAS also produces pentad and monthly oceanic fields in real time, so they are valuable dataset to serve research, application, and operational communities. A comprehensive validation of GODAS fields has been conducted using various in situ and satellite observations. It is found that the operational GODAS represents oceanic temperature and sea level variability reasonably well, but has large biases in oceanic salinity and currents. More salinity and current observations are needed for reducing the biases and estimating the validity of GODAS fields.

To serve a broad user community to use the GODAS products, a comprehensive web site (<http://www.cpc.ncep.noaa.gov/products/GODAS>) has been built with sponsorship of NOAA's Office of Climate Observation. The web site displays numerous images about historical and real time oceanic variability, and will be constantly revised to meet the needs of user communities. To demonstrate the validity of the model fields, we are conducting model-data and model-model comparisons, and plan to make some of the comparisons displayed at the web site in real time.

The GODAS fields have been used extensively in real time operation and research at NCEP. An example is shown for study of the annual cycle of the tropical Indian Ocean which not only uses the NCEP's GODAS but also those of the ECMWF and University of Maryland. The strength and weakness of various GODAS products are discussed.

**Operational NCEP Global Ocean Data Assimilation System at NCEP: the impact of  
Argo salinity and TOPEX/Jason-1 altimetry**

David Behringer, Environmental Modeling Center, NCEP/NOAA

At NCEP the primary purpose of the Global Ocean Data Assimilation System (GODAS) is to provide ocean initial conditions for seasonal to interannual (S/I) forecasting with a coupled ocean-atmospheric model. Because S/I prediction has focused on the ENSO, ocean observations in the tropical upper ocean have been most important to our operations. Also, because S/I forecasts must be calibrated by a long series of hindcasts, we require a data set that spans 20+

years. As a result we have relied heavily on ocean profiles (XBT, TAO/TRITON, Argo) and on SST (Reynolds analysis). The stability of the TAO/TRITON array since its establishment in the early 1990s and growth of the Argo array mean that *in situ* profiles retain their central importance. Although GODAS is well constrained by *in situ* data in the tropical Pacific, satellite altimetry, available since 1992, plays an important role outside of that region.

The rapid growth of the Argo array in the last few years has both increased the number of *in situ* observations used in GODAS from 5,000-6,000 per month in the 1980s and 1990s to 10,000 per month today and greatly improved the global coverage of *in situ* observations. The Argo array has also provided the first extensive global set of salinity profiles. Experiments show that when the operational GODAS, which uses a climatological TS relationship to constrain salinity, is adapted to use Argo salinity profiles, there is a measurable improvement in the GODAS salinity field and a potential improvement in tropical surface currents. The Argo array has approached full global coverage only during the last 2 years or so. Several more years will be needed before these results can be confirmed.

A consistent, uninterrupted altimetry data set from the TOPEX and Jason-1 (T/J-1) satellites has been available since late 1992, providing a good basis for testing its impact on GODAS. In the equatorial Pacific the assimilation of the TAO/TRITON mooring data already leads to a good representation of anomalous SSH in the operational GODAS. The assimilation of T/J-1 improves GODAS SSH beyond the bounds of the TAO array and well into the subtropics. In the Atlantic and Indian Oceans the operational GODAS does a poor job of representing the SSH anomaly field and appears to do no better than a Control experiment that assimilates no data. In these two oceans the assimilation of T/J1 greatly improves the GODAS SSH.

The question remains whether adding new data sets to the operational GODAS will have an impact on the NCEP S/I forecasts. An answer to this question is only possible after a data set is available for a period of many years (20+) spanning several ENSO events. Any conclusions drawn from retrospective forecasts over a shorter period of time would lack statistical reliability. In the interim, the most sensible strategy may be to work to improve both the model and the assimilation method so as to make the best possible use of the available data. Thus, from the perspective of S/I prediction, it is imperative to support not only the acquisition of new data, but also the development of improved modeling and assimilation techniques to make the best use of them.

Operational GODAS output is available at [www.cpc.ncep.noaa.gov/products/GODAS](http://www.cpc.ncep.noaa.gov/products/GODAS).

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### **Session 5: Illustrated Poster Presentations** **Chair: Sidney Thurston**

Brief, two-minute presentations were given by those who submitted an abstract affiliated with a poster displayed at the Annual System Review. See Appendix B for Poster Abstracts. A poster reception was held from 1730 to 1930 to showcase the posters presented during the illustrated poster session.

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**THURSDAY, 11 MAY 2006**

**Session 6: The State of the Ocean**  
**(based on Ch. 2 contributions – OCO Annual Report 2005)**  
**Chair: Phillip Arkin**

**Overview: Ocean Analysis and Reanalysis – Team of Experts**  
Phillip Arkin, University of Maryland, ESSIC

This presentation introduced a series of talks that presented an overview of the current state of knowledge about ocean climate in 2005, placed in historical context. Expert scientists who monitor, observe, and analyze ocean products such as sea level, ocean carbon and SST summarized events during 2005 and their historical context. The presenters described the relationship between their own findings and those from observations of other components of the ocean climate system.

This presentation covered the need for procedures that derive complete gridded fields of desired oceanic parameters from incomplete and irregularly distributed observations. This process is often called “analysis”, a term derived originally in this context from weather forecasting. To ensure that accurate historical context can be derived, “reanalyses”, in which a consistent analysis is applied to an extended sequence of past data, is generally required. The requirement for comprehensive analyses and reanalyses of the ocean and the associated components of the climate system, including the atmosphere and land surface, was discussed, and the need for a National program was explained.

**Sea Surface Temperatures in 2005 and a Daily Analysis**  
Richard W. Reynolds  
National Climatic Data Center, NOAA NESDIS, Asheville, NC

The weekly optimum interpolation analysis of Reynolds and Smith (1994) and Reynolds et al. (2002) was used to examine SST variability during 2005. The comparisons show strong summer positive anomalies in 2003, 2004 and 2005 between 50°N - 70°N. There were also strong warm anomalies (over 1°C above normal) in the summer of 2005 in the tropical North Atlantic between 10° and 20°N and between 70°W and 40°W. This region had temperatures above the minimum temperatures needed for hurricanes (~26.5°C), which may partially explain the active hurricane season for 2005.

An improved version of the SST analysis was also presented. This analysis is produced daily on a 1/4° spatial grid using in situ and satellite data with a separate step to correct any large scale satellite biases relative to the in situ data. The daily analysis uses spatial error correlation scales which are less than 1/5 the size of the weekly scales. Thus, the smaller daily spatial error scales enhance the spatial resolution.

There are two different types of satellite data used. The first is infrared satellite data from the Advanced Very High Resolution Radiometer (AVHRR). The satellite data were available as an

operational version produced by the US Navy (May et al., 1998) and a delayed reanalysis Pathfinder version (Kilpatrick, et al., 2001). Pathfinder data have lower variability than the operational data. Thus, Pathfinder AVHRR were used when available.

The second set of satellite data were obtained from the Advanced Microwave Scanning Radiometer - Earth Observing System EOS (AMSR-E) microwave satellite data from Remote Sensing Systems (RSS) (<http://www.ssmi.com>). As can be expected (see, Chelton and Wentz, 2005) the coverage of AMSR-E data are dramatically improved over AVHRR because microwave data can be retrieved under cloudy conditions as long as there is no precipitation. In particular, the impact of clouds greatly reduces AVHRR retrievals north of 40°N and south of 40°S compared to AMSR-E. Thus, an analysis with AMSR-E data has much higher variability than an analysis with AVHRR alone.

Because of the impact of AMSR-E data, there are two versions of the OI analysis. Both use in situ and AVHRR data. The first version uses AVHRR and in situ data. Pathfinder AVHRR data are used from January 1985 through December 2005 and operational Navy data are used in 2006. The second version uses AVHRR and AMSR-E satellite and in situ data. This analysis begins in June 2002 when AMSR-E data first became available. In the second version Pathfinder AVHRR data are used from June 2002 through December 2005 while operational Navy AVHRR data are used in 2006.

## References

- Chelton, D. B., and F. J. Wentz, 2005: Global microwave satellite observations of sea-surface temperature for numerical weather prediction and climate research. *Bull. Amer. Meteor. Soc.*, **86**, 1097-1115.
- May, D.A., M. M. Parmeter, D. S. Olszewski and B. D. McKenzie, 1998: Operational processing of satellite sea surface temperature retrievals at the Naval Oceanographic Office, *Bull. Amer. Met. Soc.*, **79**, 397-407.
- Kilpatrick, K. A., G. P. Podesta, R. Evans, 2001: Overview of the NOAA/NASA advanced very high resolution radiometer Pathfinder algorithm for sea surface temperature and associated matchup database. *J. Geophys. Res.*, **106**, 9179-9198.
- Reynolds, R. W. and T. M. Smith, 1994: Improved global sea surface temperature analyses. *J. Climate*, **7**, 929-948.
- Reynolds, R. W., N. A. Rayner, T. M. Smith, D. C. Stokes and W. Wang, 2002: An improved in situ and satellite SST analysis for climate. *J. Climate*, **15**, 1609-1625.

## Global Interannual Upper Ocean Heat Content Variability

Gregory C. Johnson, NOAA Pacific Marine Environmental Laboratory

In situ and satellite altimetry data were used to estimate annual upper (0-750 m) ocean heat content anomalies (OHCA) through 2005. In 2005 the subpolar N. Atlantic and a band about the Southern Ocean were both warm relative to a 1993-2003 baseline period. These changes were likely owing to large-scale wind shifts. Linear trends from 1993-2005 again involved warming of the subpolar N. Atlantic and a band around the Southern Ocean.

The global mean upper OHCA declined sharply from 2003-2005, in contrast with a relatively steady rise from 1993-2003. New error estimates that use satellite altimetry data as a proxy for OHCA suggested that the recent decline is statistically significant, as is a decline from 1980-1983

that has been reported on previously. These interannual upper OHCA variations remain largely unexplained. Evidence that the abyssal layer has warmed significantly in the S. Atlantic Ocean was presented based on comparison of a 2005 US CLIVAR/CO<sub>2</sub> repeat hydrographic program section to a 1989 WOCE section in the same location. It was suggested that the abyssal ocean might play a significant role in ocean heat content variations, highlighting the importance of repeat hydrographic sections to the ocean observing system.

### **Ocean Surface Heat Fluxes**

Lisan Yu and Robert Weller, Woods Hole Oceanographic Institution

Progress on developing improved surface heat fluxes was reported. The goal is to produce 1°x1° daily gridded fluxes for 50 years. At this point we have produced sensible and latent heat fluxes beginning in 1981. They are computed using a weighted objective analysis technique combining surface meteorology from satellite retrievals and NWP reanalyses together with the TOGA COARE 3.0 flux algorithms. This presentation gives results from initial analyses of these sensible and latent heat flux fields. Bill Rossow has made available surface shortwave and longwave radiation fields from ISCCP and these have been regridded to match the sensible and latent heat flux fields. The heat flux product we have developed, known as the OA Fluxes, is available at <http://oafux.whoi.edu>. In this presentation changes in the sensible and latent heat flux fields between 2004 and 2005 and over the last 20 years are presented, as are comparisons of the OA Fluxes with SOC, NCEP1, and ERA40 fluxes. Comparisons with *in situ* data are used to show the accuracy of the OA Fluxes and the biases in the other flux products.

A striking result is a sustained increase since 1981 in global-averaged latent heat flux, which has risen about 10 Wm<sup>-2</sup> over a time period in which global-averaged SST has also risen about 0.2°C. Sensible heat flux does not show a trend. The increase in latent heat flux is strongest in several areas, including the Gulf Stream, the Kuroshio, the central Indian Ocean, off the tip of South Africa, and off the southeast and southwest coasts of Australia. Work has begun to determine whether the increases in latent heat flux are associated with changes in surface winds or with the near-surface humidity gradient or with both. The ISCCP surface shortwave and longwave products do not show global trends; however, the ISCCP products do show biases when compared to *in situ* radiation observations and have spatial structures embedded in the fields that stem from satellite data set boundaries. The biases found between *in situ* observations and the radiation fields are large, up to 30 Wm<sup>-2</sup>. We need to continue to work on improving surface radiation fields so that their accuracy and realism match those of the sensible and latent heat flux fields.

### **State of the Ocean: Near Surface Currents**

Rick Lumpkin, NOAA Atlantic Oceanographic and Meteorological Laboratory

Near-surface currents (10-20m nominal depth, e.g., mixed layer currents) are crucial for climate as they carry mass, heat, salt and other properties over large distances as part of the wind-driven and upper limb of the overturning circulation. Advection of heat can play a major role in the upper ocean heat budgets of key regions such as the tropics, subtropical western boundary regions, Antarctic Circumpolar Current and Nordic Seas. Surface currents are measured by the observing system via drifters and moored acoustic current meters, currently covering over 60% of the ocean's surface at a nominal resolution of 600km. Current variations can also be estimated by various satellite observations.

In 2005, westward current anomalies of nearly 20 cm/s were observed in the equatorial Pacific between 120°W and the dateline, with strong monthly anomalies in the western Pacific associated with equatorial wave passage. In the Atlantic Ocean, the Florida Current and Gulf Stream were near their long-term climatological strengths.

### **The State of the Meridional Overturning Circulation**

Molly Baringer, NOAA/Atlantic Oceanographic and Meteorological Laboratory

The UK/US Observing system in the subtropical North Atlantic includes the following components: a profiling mooring array along 26.5°N, quarterly repeat high density VOS/XBT temperature sections, Florida Current monitoring, and annual CTD/LADCP and tracer sampling of the Deep Western Boundary Current. The Florida Current represents the bulk of the upper limb of the overturning circulation in the North Atlantic and transports a large amount of heat northward, with major climate implications. The Florida Current is inversely related with the North Atlantic Oscillation (NAO). High values of the NAO (low Florida Current flow) are related to milder temperatures in North America and Europe, and various precipitation and ecosystem changes in the Atlantic basin. The Florida Mean current provides data with annual mean transports showing no “collapse” of the MOC and 2005 was not an unusual year. Long-term mean transport of the Florida Current remains near 32 Sv.

Time series of temperature and salinity in the DWBC show a pronounced cold, fresh pulse of water that appeared in 1995, less than eight years after it was produced in the Labrador Sea. Results indicate a “Conveyor Belt” twice as fast as previously thought. Changes in LSW properties are linked to transport changes. LSW transport increases as the deep DWBC decreases.

In the North Atlantic, there has been an apparent decrease in heat transport over the past 10 years. Heat transport is inversely related to the Atlantic Multidecadal Oscillation (AMO) Index. Heat transports derived from XBT data are quantitatively similar to historical more expensive estimates.

### **Sea Level**

Mark Merrifield, University of Hawaii

The tide gauge network supported by OCO is used to monitor the stability of altimeter datasets for global sea level rise estimates, to examine long-term sea level change (> 10 years), and to assess coastal and short-period (< 10 days) sea level variations that are not captured by the altimeter measurements.

The global rise in sea level during 2005 was consistent with the linear trend of 2.9 +/- 0.4 mm/yr computed since 1993 from satellite altimeter measurements. This rate is higher than that determined from various analyses of long-term tide gauge records over the 20th century (~1.8 mm/yr), and current research efforts are considering whether this discrepancy represents a statistically significant acceleration in the rise rate. The altimeter-derived trends at any particular location can be quite different than the globally averaged trend due to the redistribution of ocean volume driven by surface winds. For example, sea level has been falling along the North

American coasts since 1993 due to shifting wind patterns, whereas sea level has been rising faster than the global average in areas of the western tropical Pacific.

Sea level deviations during 2005 show a high correspondence with wind curl patterns, again emphasizing that sea surface topography is strongly influenced by changes in the wind field. Sea level changes associated with surface heat fluxes or fresh-water inputs from land are weaker signals that cannot be resolved without first removing the dominant wind-driven component.

Extreme water level events in 2005 on the east and gulf coasts of the U.S. reflect the large number and severity of hurricanes and tropical storms in the region. Extreme events were characterized in terms of physical forcing (tides, seasonal variation, high frequency storms, climate variations) and quantified in terms of return periods.

### **The Global Ocean Carbon Cycle: Inventories, Sources And Sinks**

Chris Sabine, NOAA Pacific Marine Environmental Laboratory

This presentation summarized the current state of the ocean carbon observing program and illustrated a few recent intriguing findings. The carbon observing program can be divided into two broad categories of observations: repeat hydrography and surface  $p\text{CO}_2$ . The repeat hydrography project has the goal of quantifying the decadal changes in the inventory and transport of heat, fresh water, carbon dioxide ( $\text{CO}_2$ ), chlorofluorocarbon tracers and related parameters in the oceans. The program has completed 7 lines since it was initiated in 2003 and is on schedule to complete the proposed 18 line global survey by 2012. An intriguing preliminary finding from the first few cruises has been the observation that over the last decade the carbon inventory appears to be accumulating about twice as fast in the North Pacific as it is in the North Atlantic. These results are still preliminary, but represent a significant departure from the historical operation of these ocean basins. We will be able to further study this phenomenon with the latest line, P16N, which was run along  $152^\circ\text{W}$  from Tahiti to Kodiak, AK in February and March of 2006. Preliminary results from this cruise show a measurable increase in dissolved inorganic carbon (DIC) since the last occupation. This cruise also provided the first directly measured decadal change in ocean pH as further verification of ocean acidification.

The surface  $\text{CO}_2$  project has the goal of quantifying the daily to interannual variability in air-sea  $\text{CO}_2$  fluxes and understanding the mechanisms controlling these fluxes. Surface  $\text{CO}_2$  is measured on volunteer observing ships (VOS) to get a large spatial coverage and from moorings to get a high temporal coverage. The VOS project has outfitted 7 ships and has a full data exchange policy with 4 other ships. The moored  $p\text{CO}_2$  project currently has 8 open ocean systems deployed. These data are being used to develop empirical relationships between surface  $p\text{CO}_2$  and physical parameters that can be observed with a satellite (e.g. SST and winds). The satellite data can then be used to generate air-sea  $\text{CO}_2$  flux maps. A prototype global flux map based on empirical relationships from Taro Takahashi's  $p\text{CO}_2$  climatology was presented. These seasonal flux maps, covering the period from 1995 to 2004, provide a baseline assessment against which future improvements in the regional algorithms will be evaluated.

The primary oversight for both of the OCO ocean carbon observing program elements comes from PMEL and AOML, but these activities involve a large number of collaborators within the US and in the international community and these activities are intimately linked with related projects within NOAA, as part of the national Ocean Carbon and Climate Change (OCCC) Program, or as part of the international ocean carbon research agenda. A few examples include:

- Synthesis and data management activities to evaluate carbon measurements,
- Regional algorithm development to extend the surface pCO<sub>2</sub> measurements,
- Global flux map and carbon metric development to derive useful products,
- GCC funded project (GFDL, Univ. of Arizona) to assess time and space scales of surface CO<sub>2</sub> variability,
- Collaborations with ESRL and Princeton to do inverse calculations with repeat hydrography data to independently assess CO<sub>2</sub> flux estimates,
- Collaborations with WHOI on GCM model-data CO<sub>2</sub> flux comparisons,
- Developing plans for high latitude gas exchange study to improve an area of large uncertainty in flux estimates,
- Collaborations with GFDL to evaluate data assimilation approaches for Carbon.

### **Sea Ice**

Ignatius Rigor, University of Washington

The Arctic Ocean is a system under stress. The system may have been pushed passed a threshold or “tipping point” by the high AO conditions of the early 1990’s, reflected by the current persistence of younger, thinner sea ice conditions. This new state may explain the decoupling of the relationship (high correlation) that existed between the Arctic Oscillation (aka North Atlantic Oscillation) and many Arctic climate variables before 1990. This change in state may also affect global climate through the changes in export of sea ice (fresh water) to the convective regions of the Greenland and Labrador seas that drive the global THC.

Has the Arctic system passed a “tipping point” or will it rebound?

In order to answer this question and understand the changes in Arctic climate and the coupling to the global system, we need to maintain and enhance our observation network for the Arctic. There are holes in the basic observation network of the International Arctic Buoy Programme, and this network should be enhanced with ocean and sea ice mass balance buoys. These enhanced buoys are essential *in situ* observations that will help us understand the changes in sea ice mass balance (fresh water), e.g. using observations from these buoys, changes in ice thickness can be attributed to top or bottom forcing.

### **Tropical Pacific Oceanic Conditions during 2004-2006**

John E. Janowiak

Climate Prediction Center/NCEP/NWS/NOAA

During mid-2004, weak El Niño conditions developed in the central tropical Pacific and persisted until March 2005. Sea surface temperature (SST) anomalies in excess of 1°C were observed along the equator but were confined mostly to near the date line, making this a “mid-Pacific” event. During much of the period when El Niño conditions were observed, the Madden Julian Oscillation (MJO) was active. During the westerly phase of this MJO activity, westerly wind bursts over a several week period generated eastward propagating Kelvin waves that caused a deepening of the thermocline in the eastern equatorial Pacific which led to abnormally warm SSTs over that region in early 2005. Because this event was weak and was confined to the mid-Pacific, the global impacts were not strong. ENSO neutral conditions returned to the mid-Pacific in April 2005 which evolved into weak La Niña conditions in late 2005.

## **Global Oceanic Precipitation Variations in 2005**

Pingping Xie<sup>1</sup>, John E. Janowiak<sup>1</sup>, Robert Joyce<sup>1</sup>, and Phillip A. Arkin<sup>2</sup>

<sup>1</sup>NOAA/Climate Prediction Center, <sup>2</sup>ESSIC/UMD

Variations of global oceanic precipitation in 2005 have been examined using existing monitoring tools in NOAA/CPC. Distribution of precipitation anomalies during 2005 indicates a dipole pattern of wet and dry anomalies over western and eastern tropical Pacific, respectively, in association with the evolution of a weak El Niño during early 2005. A substantial positive precipitation anomaly was observed over the Gulf of Mexico and Caribbean Sea during the second half of 2005, the most active tropical storm seasons on record. Depressed precipitation, meanwhile, was present over the North Atlantic as a result of the below normal winter storm activities in the oceanic storm track. Mean precipitation for 2005, based on the CAMS-OPI estimates (Janowiak and Xie 2001), was 2.840 mm/day, equivalent to a fresh water influx of 1036.6 kg/m<sup>2</sup>.

Research and development work has been started at NOAA/CPC to improve the existing global oceanic precipitation analyses. Individual data sets of *in situ* and satellite-based precipitation have been collected and are being examined for their quantitative accuracy. Refinements of the algorithm will be performed soon to construct a suite of oceanic precipitation analyses with reduced quantitative uncertainty.

In the mean time, a brief examination of the oceanic fresh water flux generated by the NCEP Reanalysis 2 (R2) has been conducted by comparing with those derived from observations. The results show undesirable performance of the R2, in reproducing both the mean distribution and temporal variations of the fresh water flux especially over the tropical oceans.

## **Hurricanes and Atlantic Surface Flux Variability**

Mark A. Bourassa, Paul J. Hughes, Jeremy Rolph, and Shawn R. Smith

Center for Ocean-Atmospheric Prediction Studies, Department of Meteorology,  
Florida State University, Tallahassee, FL

Surface turbulent heat fluxes, driven by the mean wind speed, air/sea temperature difference, and vertical moisture gradients, are an important mechanism for transporting heat and moisture from the ocean to the atmosphere. Modulations in the large-scale atmospheric circulation and sea surface temperature patterns induce changes in latent and sensible heat fluxes over large spatial scales. The Atlantic Ocean surface heat fluxes are indicators of changes in the climate system, with links to anomalous mid-latitude storm tracks, precipitation patterns over the North Atlantic and neighboring regions, shifts in mean temperature in Florida, and modifications to the activity of the Atlantic hurricane season. This study examines the spatial and temporal variability of the surface turbulent heat fluxes over the North Atlantic (10°S-62°N) using the new objectively produced FSU3 monthly 1°x 1° gridded wind and surface flux product for 1978-2003.

The largest signal in North Atlantic surface heat fluxes appears to be linked to the Atlantic Multi-decadal Oscillation (AMO). This variability is primarily associated with changes in the magnitude and direction of winds. The AMO has been defined in terms of perturbations in the sea surface temperatures (SSTs); however, these changes have little influence on heat fluxes because of related changes in the temperature and humidity of the lower atmosphere. It is also interesting to note that the changes in wind speed occur with different timing than the changes in SSTs. The period from 1982-1997 is associated with greater surface wind speeds and greater transfer of heat

from the ocean to the atmosphere. The period from 1978 to 1981 is similar in magnitude and pattern to the period from 1998 through 2003; these periods have reduced wind speeds and heat fluxes. These variations are largely consistent with variability in the unsmoothed AMO time series. In 2005, it was interesting to note that the tropical cyclones formed in areas of relatively large latent heat flux. The recent period of increased hurricane activity (1996 through at least 2005) is largely consistent with the observed changes in surface forcing. The recent period is associated with smaller heat fluxes, but has less low-level vertical wind shear, and greater atmospheric instability, both of which make it easier for tropical disturbances to form. The reduced transfer of energy from the ocean to the atmosphere might also result in more warm water (greater ocean heat content) to power tropical cyclones.

### **Estimates of tropical cyclone heat potential (TCHP)**

Gustavo Goni, NOAA Atlantic Oceanographic and Meteorological Laboratory

Sea height anomaly fields obtained from the constellation of available altimeters are used in conjunction with historical hydrographic observations to monitor in real-time the TCHP (upper ocean heat content from the surface to the depth of the 26°C isotherm). These estimates are validated in real-time against observations obtained from *in situ* observations, such as XBTs and profiling floats. Fields similar to those presented here, but produced at the NHC, are used by the NHC in the Statistical Hurricane Intensity Prediction Scheme (SHIPS), which has shown to have consistently lower errors in intensity prediction than the GFDL model. Fields presented here are being used experimentally by the Joint Typhoon Warning Center (JTWC) in their intensity prediction models in the Pacific and Indian oceans. The TCHP fields have shown to reduce the intensity error in SHIPS for individual storms up to 20%. These fields are distributed in real-time through a NOAA/AOML web page.

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## **Session 7: Technical Requirements**

**Chair: Diane Stanitski**

### **Metadata (report from JCOMM Metadata Workshop)**

William Burnett, National Data Buoy Center

Bill Burnett presented a report on the JCOMM (Joint WMO/IOC Commission for Oceanography and Marine Meteorology) workshop to establish a pilot project to collect real-time metadata from sea surface temperatures and temperature profile data. At the meeting, the National Data Buoy Center volunteered to host a real-time metadata server and mirror a metadata server that will be operated by China's National Marine Data and Information Service as part of the pilot project.

### **DMAC & GODAE Services**

Steve Hankin, NOAA/Pacific Marine Environmental Laboratory

“GODAE Services” refers to a vision of integrated data management for ocean/climate data (including selected terrestrial observations) and analysis and reanalysis products needed to ensure maximum utility to science, operations and society. A key challenge is to support activities that

require the “fusion” of many sources of ocean data such as data-assimilation modeling and interdisciplinary research efforts.

A schematic plan for GODAE Services to integrate an Internet-connected community of distributed ocean-climate data suppliers was presented. Under the GODAE Services framework each provider will support a standardized (uniform) “service” interface to their data, complementing the data access services that the data providers may already have implemented. The uniform service allows the entire collection of data providers to be accessed through a small number of protocols, most likely based upon the OPeNDAP "DAP" (data access protocol) and the Open Geospatial Consortium (OGC) Web Feature Service (WFS) protocol. The proposed vision is an application of the tools and principles put forward in the IOOS Data Management and Communications Plan (March 2005).

### **OCO Reporting Requirements**

Joel Levy, NOAA Office of Climate Observation

Reporting requirements to the Office of Climate Observation by OCO-funded project leaders and the rationale for those reporting requirements was reviewed.

The OCO program office utilizes report content to remain well informed on current developments in observing system deployments, requirements, and findings in order to (1) participate at the cutting edge in the creation and maintenance of both national and international program plans, (2) knowledgeably represent the observing system in the NOAA and national processes of proposing and acquiring budget for the ocean observing system, (3) allocate funding in an insightful manner across individual OCO projects, and (4) justify budgets in the administrative process of moving funding to recipients.

Reporting requirements for each OCO funded project include the following:

- (1) Project Summary written for a generalist audience, describing the “who, what, why, where, and when” of the project, to be posted on the web. This is the public face of the program.
- (2) Annual Progress Report detailing what the project accomplished during the past fiscal year, including why the project was implemented (rationale), what the project achieved (accomplishments, deliverables), and why the findings matter.
- (3) Annual Work Statement and Budget Request for the coming fiscal year, including a brief articulation of the rationale for what is being proposed, a detailed description of the work proposed, an itemization of anticipated deliverables, and a detailed breakout and justification of the requested budget.
- (4) Pre-proposal for support of new activities (“Add Tasks”), comprised of a brief description of the proposed tasks and a rough estimate of their budgets.

### **Final Comments**

Take-home messages were shared by Arun Kumar, Ed Sarachik, Peter Niiler, Lisa Goddard, Ed Harrison, Maria Hood, and Kevin Trenberth who summarized and reviewed each presentation session for the meeting participants.

Wrap-up comments and announcements about the following day's Climate Observing System Council Open Session were presented by Diane Stanitski and Mike Johnson. The meeting adjourned at 1800.

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**FRIDAY, 12 MAY 2006**

**COSC Open Session – Program Review**  
**Chair: E. Harrison**

A Climate Observing System Council open session was held for meeting participants to learn about the status of current ocean observing system-related projects.

**TAO Transition**  
John Vankuren, NOAA National Weather Service

On January 1, 2006, after two months of parallel testing, NOAA's National Data Buoy Center (NDBC) became an official source of TAO/TRITON data. The URL is <http://tao.noaa.gov>. The Pacific Marine Environmental Lab (PMEL) will continue to operate as a hot backup through the rest of this fiscal year. Data availability and research continue to be unaffected by the transition. In October of 2006, the NDBC will take over at-sea maintenance of the TAO array.

A prototype and two production "refreshed" buoys will be tested in the Gulf of Mexico beginning in early summer. These buoys contain replacement sensors and communications for components of the existing TAO buoys that are becoming obsolete. NDBC and PMEL are discussing deployment of a current TAO buoy in the gulf to do some inter-comparisons and risk-reduction testing. A one-year climate parallel test of the refreshed buoy in the existing Array will begin in March 2007. Appropriated funding for building and deploying of refreshed buoys is expected in FY 2008, at about the time the one-year parallel test is completed.

**Observing System Monitoring Center \*Status Update\***  
Kevin O'Brien, NOAA/Pacific Marine Environmental Laboratory

The Observing System Monitoring Center (OSMC) is designed to be a tool which provides a system view of global ocean climate observations. At its core the OSMC, which is a partnership between three separate NOAA organizations, consists of a database of metadata. The metadata in the OSMC database includes both realtime data, as well as historical metadata dating back to 2004. As a tool, the OSMC is geared toward users in the Office of Climate Observation and observing system managers, as well as the scientific community at large.

The OSMC currently provides tools which give the user a visual overview of the observations that are being taken in the global ocean observing system, as well as the ability to drill down and discover more information about particular observations. An important next step is the evolution of the system's tools to include metrics which will be useful in the evaluation of the observing system. In addition, we are working to integrate the system with climate products, as well as with climate modeling efforts. The OSMC will be released for public use sometime in summer 2006.

## **Observing System Simulation Experiments (OSSEs)**

WGSP would like those working with the observing system to tell them what to test. Observations help to correct model errors. ODASI is the only coordinated OSSE that is known. AOML thinks the best way to support OSSEs is model-data comparison to improve models. Ocean models are less advanced than weather models. Model errors need to be improved before their results can be trusted. There was some controversy regarding how difficult it is to recommend from an OSSE that an observation should be changed, because the scale of the model is much smoothed. It was stated that it is easy with OSSEs to say what observations are inadequate. The likely conclusion from OSSEs is that our present design is inadequate.

## **COSC Executive Session**

The COSC Executive Session resulted in a series of recommendations to Mike Johnson regarding direction for the Climate Observation Program, ways to disseminate information and progress, the need for additional analysis via the Team of Experts, and increased data management and systems operations coordination.

The 4<sup>th</sup> Annual System Review of the NOAA Office of Climate Observation adjourned at 1230.

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## **Appendix A: Poster Abstracts**

### **Session 5: Illustrated Poster Presentations**

#### **POSTER ABSTRACTS**

##### **Climate Observation Program 4<sup>th</sup> Annual System Review**

**May 10-12, 2006**

**Silver Spring, Maryland**

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##### **Surface Meteorology from Volunteer Observing Ships**

by Frank Bahr, David Hosom, Albert Plueddemann, and Robert Weller  
Woods Hole Oceanographic Institution, Woods Hole, MA

At present, over much of the globe, quantitative maps of air-sea fluxes, derived either from ship reports, numerical model analyses or satellites, have errors that are large compared to the size of climatically significant signals. To address the need for accurate *in situ* observations on broad spatial scales, the Upper Ocean Processes Group at WHOI has undertaken a program of observations using a suite of Air-Sea Interaction Meteorology (ASIMET, AutoIMET) sensors adapted for installation on Volunteer Observing Ships (VOS). These systems have been installed on 5 different VOS over the last 4 years, providing a wealth of data along repeated (or nearly repeated) tracks in the Atlantic and Pacific basins. The AutoIMET system allowed an interface to NOAA SEAS 2000 (Shipboard Environmental (Data) Acquisition System), providing automated one hour satellite reports via Inmarsat C. Further details about the WHOI VOS program are available at <http://uop.whoi.edu/vos/>.

Some VOS installations were chosen because the nominal ship tracks not only passed through regions of interest for evaluating global flux products, but also passed near Ocean Reference Station (ORS) buoys operated by WHOI. The ORS buoys offer high-quality surface meteorology at fixed points, and can be used to identify biases and other errors in model and remote-sensing products. However, determining the spatial structure of the meteorological fields and associated errors requires spatial sampling as achieved by the VOS. In this presentation, we will focus on results from VOS tracks passing near the Northwest Tropical Atlantic Station (NTAS) buoy at 15°N, 51°W. Tracks from two different ships over a two-year period resulted in ten encounters where the ship passed within a 500 km radius of the buoy location. The duration of a typical encounter was about one day. Shipboard records of barometric pressure, air temperature, sea surface temperature, relative humidity and wind are compared to buoy data for each encounter. The statistics of the differences between like variables are presented along with auto- and cross-correlation analyses. Based on an understanding of the expected temporal correlation scales for each variable from the buoy time series, the goal is to assess the spatial coherence scales for the meteorology indicated by the VOS encounters.

**Keywords:** VOS, AutoIMET, flux, surface meteorology, volunteer observing ships, spatial variability

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**High Density XBT Transects in the Atlantic Ocean**  
by Molly Baringer, Gustavo Goni, and Silvia Garzoli  
NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL

NOAA/OGP funds five high-density XBT lines maintained by NOAA/AOML: 1) AX07, located along 30°N extending from the Straits of Gibraltar to Miami, 2) AX10, running between New York and Puerto Rico, 3) AX08, sampling across the Tropical Atlantic with emphasis between 30°N and 30°S, 4) AX18, running between South Africa and Argentina along 35°S, and 5) AX25, sampling between South Africa and Antarctica. These five XBT lines have been chosen to capture and monitor thermal properties within the Atlantic. The AX07 and AX18 lines have been selected to monitor the net meridional flow in the upper ocean. AX10, AX08 and AX25 are meridional lines that were selected because they cross important highly variable ocean currents, namely the Gulf Stream, the numerous Equatorial Atlantic Currents and the Agulhas and Antarctic Circumpolar Currents respectively. All XBT lines are valuable in providing estimates of the mean and time dependent temperature fields with sufficiently close spacing to sample the mesoscale field (XBTs spaced between 30-50km). They all sample various aspects of the overturning circulation and hence provide useful data on heat transport and interbasin/cross equatorial exchanges. To date, approximately 20,000 XBTs have been deployed in its high density mode in the Atlantic Ocean

Keywords: XBT, currents, temperature profiles

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**Uncertainties in Monthly Wind Fields**

by Mark A. Bourassa

The Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, FL

Uncertainties in *in situ* based monthly fields of winds of surface winds are determined and validated in comparison to satellite observations. The technique can easily be extended to fields of surface turbulent fluxes, which are critical to ocean forcing, and useful for climate studies.

Keywords: winds, fields, uncertainty

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**NDBC Observations Supporting PIRATA (NOSP)**

by Don T. Conlee

National Data Buoy Center, Stennis Space Center, MS

In May of 2005, NDBC deployed two buoys in the tropical Atlantic in support of hurricane analysis and forecasting. These buoys, along with the Woods Hole NTAS mooring, form an effective NW extension to PIRATA, complementing other ongoing PIRATA extension projects. Progress in augmenting these buoys with additional observations to support PIRATA climate objectives will be detailed, including the recent (February 2006) deployment of a companion mooring with full PIRATA-compliant subsurface instrumentation.

Keywords: PIRATA, NOSP, NDBC

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## **KEO, A Time Series Reference Site in the Kuroshio Extension Recirculation Gyre**

by Meghan Cronin and Chris Sabine  
NOAA Pacific Marine Environmental Laboratory, Seattle, WA

A surface mooring, the Kuroshio Extension Observatory (KEO), was deployed in June 2004 in the Kuroshio Extension recirculation gyre at 32.3N, 144.5E as a component of the global network of OceanSITES time series reference sites and as a component of the Kuroshio Extension System Study (KESS) process study. In this presentation, we use the KEO mooring data to assess air-sea heat flux estimates from numerical weather prediction reanalysis products. In addition, KEO data are combined with KESS data to analysis of the upper ocean heat budget at the KEO site and determine the processes involved in changes in the recirculation gyre's heat content.

Keywords: KEO, OceanSITES, mooring

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## **Web-Based Pacific Region Data and Products**

by Sharon DeCarlo, James Potemra, Yingshuo Shen, Yanli Jia, and Peter Hacker  
International Pacific Research Center, Honolulu, HI

The Asia-Pacific Data-Research Center (APDRC) provides storage and web-based access to climate data and products for climate studies. In support of the Global Ocean Data Assimilation Experiment (GODAE) and Pacific Region Integrated Data Enterprise program (PRIDE), the APDRC has started product development and data serving for Pacific island regions. This includes the implementation of a high-resolution numerical ocean model and the development of web sites and web-based data products for island communities. The Hawaiian Islands region will be used for pilot studies. One example study, done in collaboration with NOAA/PMEL, is the development of an integrated web site that compiles observations and public outreach efforts in the Hawaiian Island region. Another study involves a high-resolution, regional ocean model of circulation around Hawaii.

The APDRC has implemented product server technology consistent with OPeNDAP protocol and procedures to allow web-based access to a broad range of atmospheric and oceanic products. There are several challenges to the APDRC, including how to handle extremely large data sets, such as those from large-scale, high-resolution models, and how to best serve data from a variety of sources and formats (e.g., gridded and non-gridded data, *in situ* and remote observations, etc.) The APDRC continues to build and improve upon its data archiving and serving capabilities in order to better serve the climate researchers and the community.

This poster will present an overview of how the APDRC serves different types of datasets and will highlight web pages and data products for the Pacific, specifically those near Hawaii.

Keyword: PRIDE

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## **The NOAA Portable Seagoing Air-Sea Flux Standard**

by Chris Fairall, Dan Wolfe, and Sergio Pezoa  
PSD3 Earth System Research Laboratory, Boulder, CO

The air-sea interaction group at PSD (formerly ETL) is constructing a 3rd generation flux measurement system to use as a portable standard to promote the quality assurance of NOAA and UNOLS R/Vs and other components of the OOS (principally buoys). This poster will provide an update on progress with the design, a summary of the present architecture, and results of recent field tests.

Keywords: flux, measurement standard, intercomparison

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## **CLIVAR/CO<sub>2</sub> Repeat Hydrography Program: Initial Carbon Results from the North Pacific Ocean**

by Richard A. Feely<sup>1</sup>, Chris Sabine<sup>1</sup>, Rik Wanninkhof<sup>2</sup>, and Dana Greeley<sup>1</sup>

<sup>1</sup>NOAA Pacific Marine Environmental Laboratory, Seattle, WA

<sup>2</sup>NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL

The primary goal of the CLIVAR/CO<sub>2</sub> Repeat Hydrography Program is to quantify the role of the ocean in sequestering anthropogenic CO<sub>2</sub>. Information on shorter timescales is essential to determine any feedbacks of oceanic carbon system due to climate change, and to determine the impacts of natural variability. Discrete high-quality dissolved inorganic carbon and total alkalinity data were acquired as part of the WOCE/JGOFS Global CO<sub>2</sub> survey in the Pacific Ocean between 1991 and 1999 followed by repeat surveys in 2001 and 2004 as part of the Sub-arctic Gyre Experiment (SAGE) along the P17N line in the eastern North Pacific and the CLIVAR/CO<sub>2</sub> Repeat Hydrography Program east-west P2 cruise along 30°N. The difference between the measured DIC in the upper water column (150 - 1000 db) for the P2 2004 occupation and the 1994 occupation is shown in Figure 1. We then utilized an MLR analysis procedure to further evaluate the difference between the two cruises. Using the 1994 data set, commonly measured hydrographic quantities were inputted into the MLR analyses as the independent parameters. The total change in DIC between 2004 and 1994 is determined as the difference between the measured DIC values and those predicted from the 2004 hydrographic measurements utilizing the 1994 coefficients. The DIC difference values range between 0 - 35 μmol kg<sup>-1</sup> with the largest values occurring on the eastern edge of the basin at intermediate depths from about 100-800m depth along the 30°N. The results of these research studies suggest an annual CO<sub>2</sub> uptake of 1.0-1.4 μmol kg<sup>-1</sup> yr<sup>-1</sup> in the mixed layer, based on direct observations and multiple linear regression approaches. Deep ventilation within the Kuroshio Extension and the subsequent circulation in the subtropical gyre generates a strong east-west gradient in the anthropogenic CO<sub>2</sub> penetration depth. The combined effect of the tilted density surfaces and the younger waters with higher anthropogenic CO<sub>2</sub> concentrations leads to higher total column inventories in the western North Pacific. The integrated amount of anthropogenic CO<sub>2</sub> in the North Pacific is estimated to be 16.5 Pg C through 1994 north of the equator but not including the marginal seas. This estimate is approximately 16% of the amount of anthropogenic CO<sub>2</sub> taken by the global oceans.

Keywords: CLIVAR/CO<sub>2</sub>, Repeat Hydrography

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### **Global Sea Level Monitoring for Climate Change by NOAA's Center for Operational Oceanographic Products and Services (CO-OPS)**

by Lori Fenstermacher, Chris Zervas, and Stephen Gill

NOAA National Ocean Service (NOS) Center for Operational Oceanographic Products and Services, Silver Spring, MD

In support of the program plan objectives of NOAA's Office of Climate Observations, the Center for Operational Oceanographic Products and Services (CO-OPS) is carrying out three distinct tasks: 1) develop and implement a routine sea level analysis reporting capability for global reference stations, 2) upgrade the operation of selected CO-OPS island stations to ensure continuous operation and connection to geodetic reference frames and 3) operate and maintain water level measurement systems on Platform Harvest in support of calibration of the TOPEX/Poseidon and Jason 1 satellite altimeter missions. Progress to date and future plans will be discussed.

Keywords: sea level analysis, global reference stations, satellite altimetry calibration

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### **The State of the Ocean Climate: Towards a Measure of our Ability to Observe the Ocean**

by Albert Fischer and Gildas Mainsant

Intergovernmental Oceanographic Commission, UNESCO, Paris, France

The GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC) and the JCOMM Observations Programme Area have identified a need to develop tools for system evaluation of the sustained global ocean observing system. Eventually, an important tool for this evaluation will be the use of ocean forecast models and reanalysis models in observing system simulation experiments (OSSE). Another more immediate tool developed experimentally here are ocean climate indices that can be linked to major patterns of climate variability with significant social impact, and estimations of their uncertainty, which give an indication of our ability to measure the ocean. They also provide an at-a-glance overview of the state of the ocean climate.

These indices have been calculated using observational analyses sourced from different operational centers, and are updated on a weekly or monthly basis. Details of the scientific and social interest of the index, observational analysis sources, index calculation, and error estimation are given alongside each index. This OOPC sub-site will continue to be developed through 2006, and feedback is welcome. <http://ioc.unesco.org/oopc/>

Keywords: synthesis, climate index, global observations

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### **Unusually Warm Sea Surface Temperatures in the Tropical North Atlantic during 2005**

by Gregory Foltz and Michael McPhaden

NOAA Pacific Marine Environmental Laboratory, Seattle, WA

The 2005 Atlantic hurricane season was the most active and most destructive on record. One of the factors that likely contributed to this record-breaking season was the presence of exceptionally warm sea surface temperatures (SST) in the tropical North Atlantic. Two moored buoys, one from the Pilot Research Array in the Tropical Atlantic (PIRATA) and the other from the Northwest Tropical Atlantic Station for air-sea flux measurement (NTAS), were ideally

positioned to record the anomalous atmospheric and oceanic conditions associated with this event. Here we present results from a mixed layer heat budget analysis based on measurements from the PIRATA and NTAS buoys. We find that the primary cause of the anomalous warming was an extreme weakening of the northeasterly trade winds and an associated decrease in latent heat loss from the ocean. Secondary factors include changes in shortwave radiation and horizontal oceanic heat advection.

Keywords: tropical Atlantic, sea surface temperature, heat budget

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**New Observational Initiatives of the Tropical Ocean  
Atmosphere (TAO) Project Office**

by Paul Freitag and Michael McPhaden  
NOAA Pacific Marine Environmental Laboratory, Seattle, WA

The President's Climate Change Research Initiative included new funds in FY 06 to expand the TAO array into the Indian Ocean and to enhance tropical moored buoy array measurement programs in other basins. This poster describes these new initiatives which, in addition to the Indian Ocean expansion, include expansion of PIRATA, basin scale surface salinity measurements in TAO, enhancement of seven TAO and PIRATA sites to OceanSITES surface flux standards, and new mooring technology development. Examples of preliminary time series and analyzes are presented to illustrate the potential of these new initiatives for improving our ability to describe and understand the tropical ocean's role in climate.

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**Simulation of the ARGO Observing System**

by Igor Kamenkovich, Wei Cheng, Ed Sarachik  
University of Washington, Seattle, WA

The main goal of our study is to examine how well the ARGO observing system determines the state of the global upper ocean. Our approach is to sample and reconstruct oceanic fields from ocean general circulation models (GCMs), in gradually more realistic sequence of simulations.

Overall performance of simulated observing system is good, and the reconstructed climatology of the temperature and salinity are very close to the actual GCM-simulated values. However, all cases exhibit similarly significant differences between the reconstructed and actual fields within the Gulf Stream, Kuroshio, and the Antarctic Circumpolar Current.

Keywords: ARGO, accuracy of observing system

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**Temporal Variability of Ocean Heat Content and Salinity, 1955-2003**

by Syd Levitus<sup>1</sup>, Tim Boyer<sup>1</sup>, John Antonov<sup>2</sup>, Ricardo Locarnini<sup>3</sup>, and Hernan Garcia<sup>1</sup>

<sup>1</sup>National Oceanographic Data Center, Silver Spring, MD

<sup>2</sup>University Center for Atmospheric Research, Boulder, CO

<sup>3</sup>SP Systems, Greenbelt, MD

We describe the variability of ocean heat content for 1955-2003. In particular, the global integral of ocean heat content has decreased since 2003.

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### **Eddy-driven Mixing in the Atlantic Ocean**

by Rick Lumpkin

NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL

Eddy-driven mixing in the Atlantic mixed layer is examined using drifters. The appropriateness of an effective diffusivity for long-time dispersion is examined using 120d drifter trajectories; diffusivity is then mapped to higher resolution using 30d segments.

Lagrangian time scales vary by a factor of around 2, while length scales vary by a factor of five. To lowest order, the length scale is a function of the relatively constant time scale and the distribution of eddy kinetic energy. The distribution of diffusivity is compared to that of the baroclinic decay rate from hydrographic climatology, and results suggest a spatially varying eddy transfer length scale.

Keywords: eddy, mixing, dispersion

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### **Transport Variability along the Subtropical Atlantic Western Boundary: Implications for Monitoring the MOC**

by Christopher S. Meinen, Molly O. Baringer, Silvia L. Garzoli

NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL

At 26°N in the subtropical Atlantic a joint USA-UK program is in place to monitor the meridional transports of water and heat across the entire basin. Preliminary results from the USA/NOAA portion of the program in the western basin indicate the Deep Western Boundary Current (integrated 500 km out from the coast) and the Florida Current fluctuate by 10-40 Sv and 5-10 Sv, respectively, over periods of 2-5 months. Implications of this high level of variability for both snapshot section observations and the future time series monitoring array will be discussed.

Keywords: MOC, Florida Current, Deep Western Boundary Current

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### **Comparing Global Sea Level Rise Estimates from Satellite Altimetry and a Global Ocean Reanalysis: 1993-2001**

by Laury Miller<sup>1</sup> and Bruce C. Douglas<sup>2</sup>

<sup>1</sup>NOAA/NESDIS, Silver Spring, MD

<sup>2</sup>Florida International University, Bethesda, MD

Abstract: Satellite altimeter observations show that global sea level has been rising over the past decade at a rate of about 3 mm/yr, well above the centennial rate of 1.8 mm/yr. This has been occurring despite the presence of large geographical variations, including large areas of falling sea level. Here we investigate the global and regional nature of this signal by comparing satellite altimeter measurements of sea level change between 1993 and 2001 with estimates of the steric component of sea level change for the same period based on the SODA 1.2 reanalysis of global temperature and salinity (Carton et al., 2005).

A map comparison of the two trend data sets shows broad geographical similarities, including high positive rates (>10 mm/yr) throughout much of the western Pacific and eastern Indian

Oceans, negatives in the eastern tropical Pacific, and positives in the North Atlantic. Surprisingly, the reanalysis rates tend to have higher absolute values than the altimeter rates, particularly in the tropical Pacific. Analyzing the data sets in three zonal bands (66N to 30N, 30N to 30S, 30S to 66S) reveals distinct latitudinal differences. The northern and equatorial bands exhibit roughly similar average altimeter rates of sea level rise, at 2.5 and 2.3 mm/yr, respectively, and similar levels of correlation (~0.7) between altimeter trends and reanalysis trends on a local (grid point) basis. The southern band shows the highest average altimeter rate, at 3.9 mm/yr, suggesting that much of the increase between the centennial global rate determined from tide gauges and the 1993-2001 global altimeter-derived rate is due to rapid changes in the Southern Ocean. However, a local comparison shows that the reanalysis trends are poorly correlated with the altimeter trends in this band, making it difficult to distinguish between steric and eustatic contributions in the one band of greatest sea level rise. The poor correlation between the two data sets is probably due the lack of *in situ* hydrographic observations in the Southern Ocean, a situation which no longer exists because of the advent of the Argo program, coincidentally in 2001.

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### **NOAA Arctic Ocean Observing System: Ice Thickness Component**

by Jackie Richter-Menge<sup>1</sup>, Ignatius G. Rigor<sup>2</sup>, and John Calder<sup>3</sup>

<sup>1</sup>Cold Regions and Research Engineering Laboratory, Durham, New Hampshire

<sup>2</sup>University of Washington, Seattle, WA

<sup>3</sup>NOAA, Arctic Research Office, Silver Spring, MD

During 2003, NOAA began the deployment of an Arctic Ocean Observing System. The initial focus is to establish a network of instruments to monitor changes in the thickness, or more accurately mass balance, of the sea ice cover. This focus recognizes the role that the sea ice cover plays as both an integrator and indicator of climate-related changes in this complex atmosphere-ice-ocean system. The future objective of this component of the observing system is to maintain and develop this instrumentation network, so that 12 drifting buoys and 2 moorings are in operation at all times.

The ice thickness component of the observing network is coordinated with and complements existing activities, including the North Pole Environmental Observatory (NPEO) and the International Arctic Buoy Program (IABP). Ice thickness observations are made using drifting buoys and seafloor moorings. The drifting buoys are equipped with a thermistor string, which extends through the thickness of the ice cover, and acoustic sensors measuring the position of the top and bottom surfaces of the ice. This suite of instruments allows us to monitor and, more importantly, attribute changes in the thickness of the ice cover. The seafloor mooring is equipped with ice profiling sonar, providing a measurement of changes in the thickness of the ice cover at a particular location within the basin. Since the beginning of the program and in coordination with NPEO and IABP, a total of 17 drifting buoys have been deployed; 5 currently remain in operation. One seafloor mooring has been established in the Chukchi Sea, at (75°06' N, 168°00' W). At this point, the collective time series is too short to draw significant and specific conclusions regarding interannual and regional variability in ice mass balance. Comparisons of available data indicate that ice surface ablation is greater in the Beaufort region (67-80 cm), relative to the North Pole (0-30 cm), consistent with a longer period of melt in the more southerly location. Ablation at the bottom of the ice (22 cm), maximum ice thickness (235 cm) and maximum snow depth (28 cm) were comparable in the two regions. Data from this instrumentation network is available via the website

<http://www.crrel.usace.army.mil/sid/IMB/index.htm>. These data can be used to validate satellite-based instrumentation, for forcing, validation and assimilation into numerical climate models, and for forecasting weather and ice conditions.

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### **Forecasting the Condition of Sea Ice on Weekly to Seasonal Time Scales**

by Ignatius G. Rigor<sup>1</sup>, Magda Hanna<sup>2</sup>, Pablo Clemente-Colon<sup>2</sup>, Towanda Street<sup>2</sup>

<sup>1</sup>University of Washington, Seattle, WA

<sup>2</sup>National/Naval Ice Center, Washington, D.C.

The extent of Arctic sea ice during summer has declined to near-record minima during four of the last seven summers. Could we have predicted these past minima? We plan to answer this question, and improve our operational capability to predict the conditions of Arctic sea ice on weekly to seasonal time scales. The forecasts provided by the National/Naval Ice Center help resources managers, navigators, and hunters make better decisions regarding Arctic sea ice. Accurate sea ice information is important to naval operations, and increasing safety of life at sea.

Keywords: Arctic, sea ice, forecasts

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### **Amver Seas 2K – Ocean Data Acquisition and Transmission**

by Janet Roseli<sup>1</sup>, Paul Chinn<sup>1</sup>, Steven Cook<sup>1</sup>, Lisa Lehmann<sup>2</sup>, Carrie Wolfe<sup>3</sup>, Glenn Pezzoli<sup>2</sup>, Dean Roemmich<sup>2</sup>, Justine Afghan<sup>2</sup>, Valerie Cannon, Gary Soneira<sup>4</sup>, James Farrington<sup>1</sup>, Derrick Snowden<sup>1</sup>, Ben Kates<sup>5</sup>, and Frank Bahr<sup>6</sup>

<sup>1</sup>NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL

<sup>2</sup>Scripps Institution of Oceanography, La Jolla, CA

<sup>3</sup>Southern California Marine Institute

<sup>4</sup>NOAA Office of Oceanic and Atmospheric Research, Silver Spring, MD

<sup>5</sup>Rosenstiel School of Marine and Atmospheric Science, Miami, FL

<sup>6</sup>Woods Hole Oceanographic Institution, Woods Hole, MA

Amver Seas 2K is a real-time ship environmental data acquisition and transmission system developed by NOAA to provide accurate meteorological and oceanographic data in real-time from ships at sea through the use of satellite data transmission techniques. The data includes: Amver, Meteorological (Met), Expendable Bathy Thermograph (XBT) and Thermosalinograph (TSG) messages. It is operated on Voluntary Observing Ships, U.S. Coast Guard, and NOAA Vessels.

Amver Seas 2K was designed in three phases. Phase I, deployed December of 2000 and on 400+ ships, creates Amver and Met messages. Phase II, deployed 2003, includes Hand Launching of XBTs. Phase III, deployed 2003, includes Auto Launching of XBTs, automated weather. Phase III TSG will be deployed June 2006. More than 10,000 XBTs deployments are transmitted through Seas2K into the GTS every year. This poster shows an overview of the Seas 2K system.

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## **First Steps in Designing an Optimal Global Sampling Network for Underway Surface pCO<sub>2</sub> Measurements**

by Joellen L. Russell<sup>1</sup>, Colm Sweeney<sup>2</sup>, Anand Gnanadesikan<sup>3</sup>, Richard A. Feely<sup>4</sup>, and Rik Wanninkhof<sup>5</sup>

<sup>1</sup>University of Arizona, Tucson, AZ

<sup>2</sup>NOAA Earth System Research Laboratory, Boulder, CO

<sup>3</sup>Geophysical Fluid Dynamics Laboratory, Princeton, NJ

<sup>4</sup>NOAA Pacific Marine Environmental Laboratory, Seattle, WA

<sup>5</sup>NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL

One aspect of the effort to improve the global observing system for climate has been to expand the surface ocean pCO<sub>2</sub> measurement program to quantify our understanding of the seasonal and interannual variability of air-sea CO<sub>2</sub> fluxes. While we understand most of the major sources and sinks of CO<sub>2</sub> based on work by Takahashi et al. (2002), an optimal global pCO<sub>2</sub> sampling network design to capture temporal and spatial variability in carbon fluxes is needed. We present preliminary results of the effort to expand a region-by-region estimate of the sampling required to quantify fluxes to the nearest 0.1 Pg C/year (Sweeney et al., 2002).

Keywords: pCO<sub>2</sub>, variability

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## **Preliminary estimates of the time-variant heat budget in the Tropical Atlantic**

by Claudia Schmid, Gustavo Goni, and Rick Lumpkin

NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL

A better understanding of the mixed layer heat budget in the tropical Atlantic is important for climate research and prediction. Of particular interest are regions where the heat balance is not dominated by the surface heat fluxes. Such regions include, for example, the equatorial cold tongue and the coastal upwelling regions off Africa.

The approach is based on the analysis of a wide range of in situ and satellite observations covering the years 1997-2005. Hydrographic profiles are used to derive a time series of the monthly heat storage rate. The oceanic heat transports are derived from drifter observations in conjunction with geostrophic velocities from altimetric fields and Ekman currents from NCEP winds. The surface fluxes are from the NCEP reanalysis as well.

Preliminary results from this analysis show that good estimates of the heat budget can be derived with this approach. For example, in the tropical South Atlantic (10°S, 15°W) the difference between the heat storage rate and the net surface heat flux is on the order of 40 W/m<sup>2</sup> in boreal summer, and the peak of the heat storage rate lags behind the peak of the surface flux by about a month. When taking the advection of heat into account the phase shift is gone in most years and the difference in the boreal summer peaks is reduced to less than 10 W/m<sup>2</sup> in most years.

Keywords: heat budget, Tropical Atlantic, observations

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### **Minimet Drifter Observations in Hurricane Rita**

by Bill Scuba<sup>1</sup>, Peter Niiler<sup>1</sup>, Rick Lumpkin<sup>2</sup>, and Peter Black<sup>2</sup>

<sup>1</sup>Scripps Institution of Oceanography, La Jolla, CA

<sup>2</sup>NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL

Between 1998 and 2003 wind drifters have been deployed in the tropical Atlantic in regions where hurricanes tend to develop in strength or approach landfall. However, projection of winds from NCEP reanalysis on these drifters has revealed that, during that time period, no wind drifter south of 30°N has experienced winds in excess of 27 m/s. Starting in 2003, fifty five buoys have been deployed by air directly in front of hurricanes and have measure sea surface temperature, atmospheric pressure, wind direction, and wind speed below 25 m/s. In order to test whether wind speeds above 25 m/s and subsurface temperatures down to 100m can be measured from a drifting buoy platform, twelve standard Minimet buoys and eight Minimet buoys fitted with a 100m long temperature chains were successfully deployed on September 21, 2005 at a distance of about 24 hours in front of the projected path of a category-5 hurricane, Rita, in the vicinity of 26°N, 92°W. The resulting ocean and atmosphere measurements indicate the complex interactions that must be simulated to improve coupled hurricane intensity forecasting models.

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### **The FSU Fluxes for the Atlantic and Indian Oceans**

by Shawn R. Smith, Mark A. Bourassa, Jeremy Rolph, and Paul Hughes

The Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, FL

We will introduce a new 1° by 1° monthly turbulent flux product for the Atlantic and Indian oceans. The new Florida State University fluxes (the FSU3) are derived from *in situ* marine observations from ships, drifters, and moorings with the sea surface temperatures being extracted from the Reynolds SST fields. An objective analysis technique has been developed to produce fields of surface turbulent fluxes (momentum, latent heat, and sensible heat fluxes) and the fields used to create the fluxes (vector wind, scalar wind, near-surface air temperature and humidity, and SST). The FSU3 product moves beyond our past production of wind-only fields. The surface winds in the FSU products have been widely used in ocean modeling and ENSO prediction. The current objective approach treats the various types of observations (voluntary observing ships, moored buoys, drifting buoys) as independent, and objectively determines weights for each type of observation. Spatially the FSU3 are limited to oceans north of 30°S, due to the low observational density south of 30°S, and are available for the period 1978-2004.

The FSU fluxes provide a new set of ocean surface forcing fields which are well suited to aid in understanding the global climate system. Our long-term monthly *in situ* fields are well suited for seasonal to decadal studies. We will present initial results from spatial and temporal variability studies for the Indian and Atlantic oceans. In the Atlantic, the fluxes reveal a reversal in heat flux anomalies that appears to be associated with the phase of the Atlantic Multi-decadal Oscillation.

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## **Progress of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) Initiative**

by Shawn R. Smith

The Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, FL

Recent progress of the SAMOS Initiative will be provided. The SAMOS data center will report on results of the 2005 pilot project, including updates on vessels contributing observations, the ship profile database, and issues that arose during initial implementation. The data center will outline plans to recruit additional vessels, expand data distribution, and advance data quality evaluation. An update from NOAA ESRL/PSD and WHOI will describe the development status of the portable standard instrument system. Progress on accuracy standards for marine meteorological observations will also be discussed. A draft of the "Guide to making climate quality meteorological and flux measurements at sea" is currently undergoing review and this guide will be outlined. Finally, draft recommendations of the 1<sup>st</sup> Joint GOSUD/SAMOS workshop will be presented, if possible (the workshop concludes only 6 days prior to the OCO Annual Meeting).

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## **Decadal Changes in Inorganic Carbon in the Atlantic Ocean**

by Rik Wanninkhof<sup>1</sup>, Scott Doney<sup>2</sup>, Chris Langdon<sup>3</sup>, John L. Bullister<sup>4</sup>, Gregory C. Johnson<sup>4</sup>, and Frank Millero<sup>3</sup>

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As part of the CLIVAR/CO<sub>2</sub> Repeat Hydrography Program a meridional transect was occupied through the middle of the Atlantic ocean from 63°N to 60°S measuring key hydrographic, biogeochemical parameters and transient tracers over the full water column. The results from the northern and southern sections, completed in 2003 and 2005, respectively are compared to data from cruises along these sections during the late 1980's and early 1990's. The imprint of the anthropogenic CO<sub>2</sub> invasion over the last decade is reflected by an increase in inorganic carbon (DIC) in the upper 1000 m.

Keywords: Atlantic, CLIVAR/CO<sub>2</sub>, inorganic carbon

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## **Delayed Mode XBT Data Handling at AOML**

by Anne-Marie Wilburn, Robert Molinari and Joaquín Trínanes

NOAA Atlantic Oceanographic and Meteorological Laboratory, Miami, FL

This poster is a descriptive representation that shows:

- 1) The XBT data flow through AOML
- 2) The number of XBT data submitted
- 3) Spatial coverage of the XBT data

The poster displays a chart showing the principal GOOS XBT routes that allows visualization of the exact areas of the ocean from which the XBT observations are taken. A histogram exhibiting the number of total XBT observations (in real time and delayed mode) recorded by AOML since 2000 – present is included to show a yearly data comparison of the data received from Voluntary Observing Ships. This poster also shows how the delayed mode XBT data is handled once it is received at AOML, i.e., checked for errors in dates, call signs, etc.; and how the data are distributed once it is reviewed and checked for errors. It is also shown how the delayed mode XBT data are placed into circulation since it is not immediately transferred to the GTS, as is the case of the real time XBT data.

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### **Global Dataset of Shallow and Deep Velocities Derived from Argo Floats**

by Hiroshi Yoshinari, Nikolai A. Maximenko, and Peter Hacker

University of Hawaii, International Pacific Research Center, Honolulu, HI

The poster announces the availability of the new dataset, YoMaHa'05, recently released to the public. The dataset contains estimates of velocities for surface and deep currents obtained using data from the trajectories of Argo floats. It includes data from 3039 floats stored in nine Data Assembly Centers (DACs) worldwide and almost 167,000 values of velocity. The data span the period from 4 August 1997 through the end of 2005. Surface velocities are linearly regressed from float coordinates fixed by the ARGOS satellites. Deep velocities are estimated from float displacements during each submerged phase of the cycle. Both surface and deep velocities are accompanied by error estimates, which are typically an order of magnitude smaller than velocity values. The poster briefly describes: the method for estimating velocities; the data distribution in space and time; velocity characteristics in terms of the probability distributions of velocities and errors; and applications and future plans. The dataset and technical report are available at: <http://apdrc.soest.hawaii.edu/projects/yomaha05/index.html>.

Keywords: Argo float velocities, surface/deep currents, global ocean dataset

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## Appendix B: Agenda and Letter of Invitation

### AGENDA

## NOAA Climate Observation Program 4<sup>th</sup> Annual System Review

Theme: Advancing the System to Address Ocean Analysis Needs

10-12 May 2006



NOAA Office of Climate Observation



**Climate Observation Program Annual System Review**  
**Theme: Advancing the System to Address Ocean Analysis Needs**  
**10-12 May 2006**

**WEDNESDAY, 10 MAY 2006**

All activities will take place on the 4<sup>th</sup> floor of the Crowne Plaza in the Kennedy Ballroom.

0800    Coffee, Continental Breakfast                      4<sup>th</sup> Floor Adams Room  
         Poster set-up    Grant I and II

**0825    Session 1: Overview    Chair: M. Johnson**

0825    Welcome (5 min)    M. Johnson

0830    Putting the “O” in NOAA (20 min)    A. Leetmaa

0850    The Climate Observation Program;  
         Program Planning, Performance Metrics, Budget (30 min)    M. Johnson

**0920    Session 2: Users    Chair: E. Sarachik**

0920    CLIVAR – observing system needs of the research community (20 min) R. Weller

0940    Observing System Simulation Experiments – GFDL (20 min)    G. Vecchi

1000    Observations in Support of Climate Risk Management at IRI (20 min)    L. Goddard

1020    CLIVAR Working Group on Seasonal to Interannual Prediction (20 min) D. DeWitt

**1040    Break (20 minutes)**

**1100    Session 3: Panel Session and Discussion – Ocean Observing System Applications**  
How does the ocean influence drought, Atlantic circulation, and hurricane development/intensity? Do researchers studying these issues need an ocean observing system? If so, what ocean observations are necessary? (1 hr, 45 min)

**Topics and Panelists    Chair: E. Sarachik**

**Attribution Evidence for Oceanic Forcing of Regional Droughts**  
Martin Hoerling (NOAA-Earth System Research Laboratory)

**Early Detection/Prediction Of Ocean Circulation Changes: Implications For The Design Of Ocean Observation Systems**  
Klaus Keller (Pennsylvania State University)

**Hurricane Forecasting (CBLAST)**  
Peter Black (NOAA, Hurricane Research Division)

**1245    LUNCH on your own (1 hr, 15 min)**

**1400 Session 4: Assimilating Data – Collaborations and Applications Chair: E. Harrison**

1400 The Link between Satellite and In Situ Observations (30 min) K. Casey

1430 NOAA's Plan to Address Satellite Needs Identified in the GCOS Implementation Plan (30 min) S. Wilson

1500 Operational NCEP Global Ocean Data Assimilation System at NCEP: The Link, Validation, and Application (30 min) D.Behringer/Y.Xue

**1530 Break (20 minutes)**

**1550 Session 5: Illustrated Poster Presentations (60 min) Chair: S. Thurston**

1650 Adjourn

**1730 - 1930 Reception with Poster Viewing in Grant I and II**

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**THURSDAY, 11 MAY 2006**

0800 Coffee, Continental Breakfast 4<sup>th</sup> Floor Adams Room  
Poster viewing Grant I and II

**0830 Session 6: The State of the Ocean (based on Ch. 2 contributions – OCO Annual Report 2005) Chair: P. Arkin**

0830 Overview: Ocean Analysis and Reanalysis – Team of Experts (20 min) P. Arkin

**0850 Temperature**

0850 Sea Surface Temperature (20 min) R. Reynolds

0910 Global Interannual Upper Ocean Heat Content Variability (20 min) G. Johnson

0930 Heat Fluxes (20 min) L. Yu

0950 Discussion (30 min)

**1010 Break and Poster Viewing in Grant I and II (20 minutes)**

**1030 Ocean Circulation**

1030 Surface Currents (20 min) R. Lumpkin

1050 Thermohaline Circulation (20 min) M. Baringer

1110 Sea Level (20 min) M. Merrifield

1130 Discussion (30 min)

**1200 LUNCH on your own (1 hr, 10 min)**

- |      |  |             |
|------|--|-------------|
| 1310 | The Global Ocean Carbon Cycle (20 min)                                 | C. Sabine   |
| 1330 | Sea Ice (20 min)   | I. Rigor    |
| 1350 | El Nino: Tropical Pacific Oceanic Conditions during 2004-2006 (20 min) | J. Janowiak |
| 1410 | Discussion (30 min)  |             |

**1440 Break and Poster Viewing in Grant I and II (20 minutes)**

- |      |   |             |
|------|---|-------------|
| 1500 | Precipitation (20 min)                                    | P. Xie      |
| 1520 | Hurricanes and Atlantic Surface Flux Variability (20 min) | M. Bourassa |
| 1540 | Tropical Cyclone Heat Potential (20 min)                  | G. Goni     |
| 1600 | Discussion (30 min)                                       |             |

**1630 Session 7: Technical Requirements**

**Chair: D. Stanitski**

- |      |   |            |
|------|---|------------|
| 1630 | Metadata (report from JCOMM Metadata Workshop) (20 min)                               | W. Burnett |
| 1650 | DMAC and GODAE Services (20 min)  | S. Hankin  |
| 1710 | Annual Report Overview and Reporting Requirements (15 min)                            | J. Levy    |
| 1725 | Take-Home Messages<br>- overview of days 1 & 2<br>- needs to be discussed by the COSC |            |

**1800 Meeting Adjourns**

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**FRIDAY, 12 MAY 2006**

0800    Coffee, Continental Breakfast                      4<sup>th</sup> Floor Adams Room

**0830    COSC Open Session – Program Review (120 min)**                      **Chair: E. Harrison**  
            TAO Transition – John Vankuren  
            OSMC – Kevin O’Brien  
            OSSE  
            GODAE Services

**1030    *Break (20 minutes)***

**1050    COSC Executive Session (100 min)**

**1230    COSC Adjourns**

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## **Letter of Invitation**

February 24, 2006

Dear Ocean Observing System Colleagues:

You are invited to participate in the NOAA Climate Observation Program 4<sup>th</sup> Annual System Review, scheduled from May 10-12, 2006. Please note that these dates have shifted by one day (an adjustment from the initial announcement sent on December 9). This meeting will help provide direction so that NOAA can continue making positive contributions to the integrated global ocean observing system. We are proud to announce that with your hard work the ocean observing system has surpassed 55% completion.

The theme of the Annual System Review will be *Advancing the System to Address Ocean Analysis Needs*. Some highlights on the agenda during the first two days include a panel session focused on ocean observing system applications, illustrated poster presentations, and summary reports on the current state of the ocean given by members of the Team of Experts. In addition, satellite collaboration, data assimilation, user applications, and technical requirements for the ocean observing system will be emphasized. The third day will include an open session of the Climate Observing System Council (COSC), to which you are all invited, followed by a COSC Executive Session.

Once again this year, we ask you to register for the Annual System Review on-line by accessing the website, <http://www.ocreview.noaa.gov>. When prompted, enter the following for the username and password:

Username: OCO (all uppercase)

Password: register (all lowercase)

Once there, please click on "Registration". This year, all oral presentations are invited, but there is an opportunity to present an illustrated poster. If you do wish to bring a poster, you will be prompted to include a poster abstract. **Please register for the meeting no later than Friday, March 31 if you plan to bring a poster so we can reserve the necessary number of poster boards.**

### **Illustrated Posters**

Similar to last year's meeting, you are invited to create a poster to highlight your network/project accomplishments. An illustrated poster session is scheduled for Wednesday afternoon when each poster presenter will be allotted two minutes and one visual (overhead transparency or PowerPoint slide) to provide a brief poster introduction for the meeting participants. We will have both an overhead and computer projector available for your use.

- If you plan to show a PowerPoint slide as your visual during your 2-minute overview, please email the slide to [diane.stanitski@noaa.gov](mailto:diane.stanitski@noaa.gov) by Monday, May 8 (please mark your calendars now) so that it can be saved and placed in order on the workshop computer. *If you would like to contribute more than one poster, please clearly label your slide with the title of the poster and author(s) and send a separate slide for each poster.*
- Please make 40 (8-1/2" x 11") color copies of your poster to distribute to workshop participants during the poster session.
- By May 17, email your poster to [diane.stanitski@noaa.gov](mailto:diane.stanitski@noaa.gov) as a PowerPoint slide or pdf to be included on the OCO web site ([www.oco.noaa.gov](http://www.oco.noaa.gov)).

Thank you for your interest in contributing to the Annual System Review. We appreciate your time and will all greatly benefit from your poster presentations.

**Meeting Logistics**

The location for all events is the Crowne Plaza (formerly the Holiday Inn) in Silver Spring, Maryland. The hotel address is:

**Crowne Plaza  
8777 Georgia Avenue  
Silver Spring, MD 20910  
Tel: 1-301-589-0800, Fax: 1-301-587-4791**

- Rooms are reserved for our group at a cost of \$180/night. This rate is guaranteed through 3:00 pm on April 17. When you call the Crowne Plaza to make reservations, state that you are with the *Climate Observation Program* to receive the discounted rate.
- A hotel parking garage is available. The rate for hotel guests and conference attendees is \$10.00 per day.
- Public transportation (Silver Spring metro stop and bus station) is within walking distance.

A continental breakfast and coffee/tea will be available each morning starting at 0800 just adjacent to the meeting room. Lunch will be on your own; a local restaurant guide will be provided at the meeting. Please plan to join us for a poster reception scheduled for Wednesday evening.

The closest airports are Ronald Reagan (National), Baltimore Washington International (BWI), and Dulles (IAD). If you fly into National you can take the metro to Silver Spring. If you need directions regarding how to most easily travel to/from an airport, please email and we will be happy to send you details. Information is also available on the meeting registration website.

If it is necessary for you to ship material to the Crowne Plaza prior to the Annual System Review, please mark your package clearly with:

Crowne Plaza Washington Silver Spring  
8777 Georgia Avenue  
Silver Spring, MD, 20910  
Hold For: Name of Guest, Name of Conference, Dates of Conference

**Summary**

A draft agenda for the Annual System Review is attached to this message. We will be developing the final agenda over the next three months. If you believe that an important participant has been missed on the invitation list, please forward this letter to him/her and let us know so we can add to the mailing list. Thanks. We look forward to your participation at the Climate Observation Program 4<sup>th</sup> Annual System Review.

Best wishes,  
Diane Stanitski

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## Appendix D: Climate Observing System Council (COSC)

The Climate Observing System Council reviews the Climate Observation Program's contribution to the international Global Climate Observing System to recommend effective ways for the Program to respond to the long-term observational needs of the Operational Forecast Centers, International Research Programs, and major Scientific Assessments. The Council meets at least annually and is comprised of members both internal and external to NOAA who offer their expert advice. The term of membership is two years with a renewal option for two additional terms.

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## Appendix E: List of Acronyms

AAAS	American Association for the Advancement of Science
ABL	Atmospheric Boundary Layer
ADCP	Acoustic Doppler Current Profiler
ADP	Adopt a Drifter Program
AGU	American Geophysical Union
AMMA	African Monsoon Multidisciplinary Analyses
AMS	American Meteorological Society
AMSR	Advanced Microwave Scanning Radiometer
AMSU-B	Advanced Microwave Sounding Unit – Channel B
AMVER	Automated Mutual assistance Vessel Rescue system
AOML	Atlantic Oceanographic and Meteorological Laboratory
APDRC	Asia-Pacific Data Research Center
APL	Applied Physics Laboratory
ARCs	Applied Research Centers
ArcIMS	Arc Internet Map Server
ARPEGE-CLIMAT	Climate Research Project on Small and Large Scales (France)
ASIMET	Air-Sea Interaction Meteorology system
BAKOSURTANAL	National Coordinating Agency for Surveys and Mapping, Indonesia
BATHY	Bathythermograph format for data exchange
BMRC	Bureau of Meteorology Research Centre (Australia)
BoM	Bureau of Meteorology (Australia)
BPR	Bottom Pressure Recorder
BSH	Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency) (Germany)
CARINA	CARbon dioxide IN the Atlantic
C&GC	Climate and Global Change
CCHCO	CLIVAR and Carbon Hydrographic Data Office
CCRI	Climate Change Research Initiative
CCSP	Climate Change Science Program
CDC	Climate Diagnostics Center
CDIAC	Carbon Dioxide Information Analysis Center
CDP	Climate Data Portal
CEOF	Complex Empirical Orthogonal Function
CFD	Computer Flow Dynamics
CGPS	Continuously Operated GPS
CICOR	Cooperative Institute for Climate and Ocean Research
CIMAS	Cooperative Institute for Marine and Atmospheric Studies
CIRES	Cooperative Institute for Research in Environmental Sciences
CLIPS	Climate Information and Prediction Services Project
CLIVAR	CLimate VARIability and Predictability
C-MAN	Coastal-Marine Automated Network
CMAP	CPC Merged Analysis of Precipitation
CMORPH	CPC MORPHing Technique
COLA	Center for Ocean, Land, and Atmosphere Studies
COAPS	Center for Ocean-Atmospheric Prediction Studies
COOP	Coastal Ocean Observations Panel (GOOS)
COP	Climate Observation Program
CORC	Consortium on the Ocean's Role in Climate
COSC	Climate Observing System Council

COSP	Climate Observations and Services
CLIVAR	Climate Variability and Predictability Program
CPC	Climate Prediction Center
CPO	Climate Program Office
CPPA	Climate Prediction Program for the Americas
CPRDB	Comprehensive Pacific Raining Database
CSIRO	Commonwealth Scientific and Industrial Research Organization
CTD	Conductivity, Temperature, Depth
DAC	Data Assembly Center
DART	Deep Ocean Assessment and Reporting of Tsunamis (Buoy)
DBCP	Data Buoy Cooperation Panel
DCP	Data Collection Platform
DCS	Data Collection System
DMC	Drought Monitoring Center
DODS	Distributed Ocean Data System
DOE	Department of Energy
DSL	Digital Subscriber Line
DWBC	Deep Western Boundary Current
ECCO	Estimating the Circulation and Climate of the Ocean
ECMWF	European Centre for Medium-Range Weather Forecasts
ENSO	El Niño-Southern Oscillation
EOF	Empirical Orthogonal Function
EPIC	Eastern Pacific Investigation of Climate
ERA40	ECMWF ReAnalysis-40
ERS	Earth Remote-sensing Satellite
ESDIM	Environmental Services Data and Information Management (NOAA)
ESRI	Environmental Systems Research Institute
ETL	Environmental Technology Laboratory
EVAC	Environmental Verification and Analysis Center
FAO	Food and Agriculture Organization (UN)
FGDC	Federal Geographic Data Committee
FLOAT	Argo subsurface profiling floats
FRX	Frequently Repeated XBT
FS	Frequently Sampled Line
FSU-COAPS	Florida State University Center for Ocean-Atmosphere Prediction Studies
FTE	Full Time Equivalent
FY	Fiscal Year
GAINS	GLOSS Development in the Atlantic and Indian Oceans
GAPP	GEWEX Americas Prediction Project
GCC	Global Carbon Cycle
GCOS	Global Climate Observing System
GCP	Global Carbon Project
GCTE	Global Change and Terrestrial Ecology Program
GCRMN	Global Coral Reef Monitoring Network
GDC	Global Drifter Center
GDP	Global Drifter Program
GEOSAT	Geodesy Satellite
GEWEX	Global Energy and Water-cycle Experiment
GFDL	Geophysical Fluid Dynamics Laboratory
GIS	Geographic Information System
GLOSS	Global Sea Level Observing System

GODAE	Global Ocean Data Assimilation Experiment
GODAR	Global Oceanographic Data Archaeology and Rescue Project
GOES	Geostationary Operational Environmental Satellite
GOOS	Global Ocean Observing System
GOSUD	Global Ocean Surface Underway Data project
GPCP	Global Precipitation Climatology Project
GPS	Global Positioning System
GPS@TG	Co-located GPS systems at tide gauge stations
GSOP	Global Synthesis and Observations Panel of CLIVAR
GTS	Global Telecommunications System
GTSP	Global Temperature-Salinity Profile Program
HD	High Density Line
HRX	High Resolution XBT
HURDAT	Atlantic Basin Hurricane Database
IAI	Inter-American Institute for Global Change Research
ICODS	International Comprehensive Ocean-Atmosphere Data Set
IDOE	International Decade of Ocean Exploration
IES	Inverted Echo Sounder
IFREMER	Institut français de recherche pour l'exploitation de la mer (French Research Institute for Exploitation of the Sea) (France)
IGBP	International Geosphere-Biosphere Programme
IGCO	Integrated Global Carbon Observing team
IHO	International Hydrographic Organization
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research
IMET	Improved METeorological instrument
IMMA	International Maritime Meteorological Archive format
IOC	Intergovernmental Oceanographic Commission
IOCCP	International Ocean Carbon Coordination Project
IODE	International Oceanographic Data and information Exchange
IOOS	Integrated Ocean Observing System
IOOS-DMAC	Integrated Ocean Observing System – Data Management and Communication
IOTWS	Indian Ocean Tsunami Warning System
IPRC	International Pacific Research Center
IPY	International Polar Year
IR	Infrared
IRD-Brest	L’Institut de recherché pour le developpement – Brest (France)
IRI	International Research Institute for Climate Prediction
ISCCP	International Satellite Cloud Climatology Project
ITCZ	Inter-Tropical Convergence Zone
IUGG	International Union of Geodesy and Geophysics
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JASL	Joint Archive for Sea Level
JASON	Not an acronym but the name of a join French/US altimeter mission
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
JCOMMOPS	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology Observing Platform Support
JGOFS	Joint Global Ocean Flux Survey
JIMAR	Joint Institute for Marine and Atmospheric Research, University of Hawaii
JIMO	Joint Institute for Marine Observations
JISAO	Joint Institute for the Study of the Atmosphere and Ocean

JMA	Japan Meteorological Agency
J-OFURO	Japanese Ocean Flux data sets with Use of Remote sensing Observations
JPL	Jet Propulsion Laboratory
JTA	Joint Tariff Agreement
KE	Kuroshio Extension
KEO	Kuroshio Extension Observatory
KESS	Kuroshio Extension System Study
LAS	Live Access Server
LD, LDX	Low Density Sampling Line
LLNL	Lawrence Livermore National Laboratory
MAN	Management Committee (JCOMM)
MAO	Marine and Aviation Operations (NOAA)
MBT	Mechanical Bathythermograph
MEDS	Marine Environmental Data Services
MICOM	Miami Isopycnic Coordinate Ocean Model
MJO	Madden-Julian Oscillation
MOC	Meridional Overturning Circulation
MOCHA	Meridional Overturning, Circulation and Heat Transport Array
MOU	Memorandum of Understanding
MS	Microsoft
NACP	North American Carbon Program
NAO	North Atlantic Oscillation
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
ncBrowse	Graphical netCDF File Browser
NDBC	National Data Buoy Center
NCDC	National Climatic Data Center
NCDDC	National Coastal Data Development Center
NCEP	National Centers for Environmental Prediction
NEAR-GOOS	North-East Asian Regional GOOS
NERC	National Environmental Research Council
NESDIS	National Environmental Satellite, Data, & Information Service
netCDF	network Common Data Form
NGDC	National Geophysical Data Center
NGO	Non-Governmental Organization
NIC	National Ice Center
NIH	National Institutes of Health
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
NMFS	National Marine Fisheries Service
NMHS	National Meteorological and Hydrological Services
NMRI	Naval Medical Research Institute
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOPP	National Ocean Partnership Program
NORPAX	North Pacific Experiment
NOS	NOAA Ocean Service
NOSA	NOAA Observing System Architecture
NRC	National Research Council
NSCAT	NASA Scatterometer
NSF	National Science Foundation
NTC	National Tidal Centre, Australia

NWP	Numerical Weather Prediction
NWS	National Weather Service
NWS-PR	National Weather Service Pacific Region
NVODS	National Virtual Ocean Data System
MON	NWS Marine Observation Network
OAFIux	Objectively Analyzed air-sea heat Fluxes
OAR	Office of Oceanic and Atmospheric Research
OSCC	Ocean Carbon and Climate Change Program
OSCI	Ocean Climate Change Institute
OceanSITES	Ocean Sustained Interdisciplinary Time series Environmental Observatory
OCO	Office of Climate Observation
ODINAFRICA	Ocean Data and Information Network for Africa
OGP	Office of Global Programs
OMAO	Office of Marine and Aviation Operations
OOPC	Ocean Observations Panel for Climate
OpenDAP	Open Source Project for Network Data Access Protocol
OSMC	Observing System Monitoring Center
PacificGOOS	Pacific Global Ocean Observing System
PACIS	Pan-American Climate Information System
PACS	Pan American Climate Studies
PCES	North Pacific Marine Science Organization
PDO	Pacific Decadal Oscillation
PEAC	Pacific ENSO Applications Center
PHOD	Physical Oceanography Division
PIES	Pressure Gauge Equipped Inverted Echo Sounder
PIRATA	Pilot Research Moored Array in the Tropical Atlantic
PMEL	Pacific Marine Environmental Laboratory
PMO	Port Meteorological Officer
PNA	Pacific North America
PNNL	Pacific Northwest National Laboratory
POGO	Partnership for the Observation of the Global Oceans
PP&I	Program, Planning & Integration
QA	Quality Assurance
QSCAT	Seawinds on QuikScat
RRP	ENSO Rapid Response Project
RSMAS	Rosenstiel School of Marine and Atmospheric Science
R/V	Research Vessel
RVIB	Research Vessel / Ice Breaker
RVSMDC	Research Vessel Surface Meteorology Data Center
SABOM	South African Bureau of Meteorology
SAC	Special Analysis Center
SAF	Subantarctic Front
SAMOS	Shipboard Automated Meteorological and Oceanographic System
SAR	Synthetic Aperture Radar
SAZ	Subantarctic Zone
SCPP	Seasonal-to-Interannual Climate Prediction Program
SCMI	Southern California Marine Institute
SCOR	Scientific Committee for Ocean Research
SDE	Spatial Database Engine
SEACOOS	Southeast Atlantic Coastal Ocean Observing System
SEAFLUX	Ocean Surface Turbulent Flux Project

SEARCH	Study of Environmental Arctic Change
SEAS	Shipboard Environmental data Acquisition System
SEAS	Windows version of the SEAS shipboard software
SEC	South Equatorial Current
SERREAD	Scientific Educational Resources and Experience Associated with the Deployment of Argo profiling floats in the South Pacific Ocean
SI	Seasonal-to-Interannual
SIO	Scripps Institution of Oceanography
SIO-ECPC	Scripps Institution of Oceanography-Experimental Climate Prediction Center
SLP	Sea Level Pressure
SLP-PAC	Sea Level Program in the Pacific
SOC	Southampton Oceanography Centre
SOI	Survey of India
SOLAS	Surface Ocean-Lower Atmosphere Study
SOOP	Ship-of-Opportunity Program
SOOPIP	Ship-of-Opportunity Implementation Panel
SOI	Southern Oscillation Index
SOT	Ship Observations Team
SPARCE	South Pacific Rainfall Climate Experiment
SPCZ	South Pacific Convergence Zone
SRDC	Surface Reference Data Center
SSG	Scientific Steering Group
SSM/I	Special Sensor Microwave Imager
SSP	Sea Surface Pressure
SST	Sea Surface Temperature
START	Global Change System for Analysis, Research, and Training
STD-C	Standard C
STF	Subtropical Front
SURFRAD	Surface Radiation Budget Network
TAO	Tropical Atmosphere Ocean Array
TAV	Tropical Atlantic Variability
TESAC	Temperature, Salinity, Currents (format for data exchange)
TMI	TRMM Microwave Imager
TOGA	Tropical Ocean Global Atmosphere Program
TOGA/COARE	Tropical Ocean Global Atmosphere / Coupled Ocean-Atmosphere Response Experiment
TOPEX	Ocean TOPography Experiment
TRACKOB	Track observation
TRITON	Triangle Trans-Ocean Buoy Network
TRMM	Tropical Rainfall Measurement Mission
TSG	Thermosalinograph
UHSLC	University of Hawaii Sea Level Center
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change
UNOLS	University – National Oceanographic Laboratory System
UOT	Upper Ocean Thermal
UOTC	Upper Ocean Thermal Center
UPS	Uninterruptible Power Supply
URI	University of Rhode Island
USB	Universal Serial Bus
USCG	United States Coast Guard

USIABP	U.S. Interagency Arctic Buoy Program
USGCRP	U.S. Global Change Research Program
UW	University of Washington
VOS	Volunteer Observing Ship
VOSclim	WMO Volunteer Observing Ship Climate project
WCRP	World Climate Research Program
WDC-A	World Data Center-A for Oceanography
WFS	Web Feature Service
WGASF	Working Group on Air-Sea Fluxes
WHO	World Health Organization
WHOI	Wood's Hole Oceanographic Institution
WMO	World Meteorological Organization
WMS	Web Map Service
WOCE	World Ocean Circulation Experiment
WWE	Westerly Wind Event
WWW	The World Weather Watch of WMO
XBT	Expendable Bathythermograph
XCTD	Expendable Conductivity Temperature Depth